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Fast track participatory approach to release of elite cassava genotypes for various uses in Nigeria's cassava economy

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Abstract The aim of the Integrated Cassava Project (ICP) of the International Institute of Tropical Agriculture was to pre-emptively manage the cassava mosaic disease (CMD) to avert an imminent and increasing possible threat of the Ugandan strain of the CMD virus of the pathogen from doing damage to the Nigerian cassava economy. The strategy was to engage in activities that would lead to cultivar-substitution by replacing the susceptible varieties on farmers' fields with superior genotypes that are not only CMD resistant or tolerant but also high yielding with good dry matter content. A fast track participatory selection approach was used in 2 years to release nine new lines in Nigeria. It was intensive and several lessons were learnt. The varieties released after 2 years were TMS 98/0510, TMS 98/0581, TMS 97/2205, TMS 98/0505, TME 419, TMS 92/0326, TMS 96/1632, TMS 98/0002, and TMS 92/0057.

Keywords Cassava Mosaic disease · *Manihot esculenta* · Variety release · Variety selection · Nigeria

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Introduction

Cassava (*Manihot esculenta* Crantz) is an important root crop in Nigeria. It serves as staples for many households and recently is being promoted as an industrial crop in Nigeria. In 2002, the International Institute of Tropical Agriculture (IITA) raised a threat alarm of the new Ugandan virus strain (EACMV-Ug2) of cassava mosaic disease (CMD) entering Nigeria (Ogbe et al. 2002). The Government of Nigeria, United States Agency for International Development (USAID), and Shell Petroleum Development Company of Nigeria (SPDC) responded

consequently by funding the setting up of the Integrated Cassava Project (ICP).

The expected output of ICP was to mitigate the impact of CMD and prevent its spread throughout Nigeria, and to increase cassava productivity by deploying high yielding cultivars and proven technologies for sustainable crop and soil management.

This paper presents how the ICP selected new elite clones for release to farmers, taking into cognisance the stability of the clones over varying environments, increased productivity, acceptability, and adoptability. It documents the institutional constraints encountered, and the lessons learnt in the form of advantages and disadvantages of the selection approach that was utilized.

Justification for the fast-track participatory selection approach

The justification of the fast-track participatory selection approach (FTPSA) utilized by ICP was as follows:

- The threat of the new Ugandan virus strain (EACMV-Ug2) entering Nigeria was real, in that the two viral strains (ACMV and EACMV) which can recombine to produce the EACMV-Ug2 had been spotted in Nigeria (Ogbe et al. 2002).
- The mega initiatives for cassava launched in Nigeria would lead to an increase in the movement and cultivation of susceptible cassava stakes. Failure of this laudable initiative in the country as a result of disease devastation could destabilize the subregion.
- These initiatives also required the development of commercial farmers whose primary objective was to supply fresh roots to industries, thus, there had to be a quick and aggressive replacement of cassava varieties currently being grown by farmers in the country that were susceptible to CMD.

Institutional constraints

For the task ICP had to do required cultivar substitution, and the most important constraint was the fact that IITA cannot release a cassava variety in Nigeria. IITA can request for release of a variety through the National Root Crops Research Institute (NRCRI) which is the national body responsible for root crops development. The variety release process in Nigeria requires several years of testing materials on-station, at least 2 years of out-station trials as multilocational trials, demonstration trials, and on-farm trials before evaluation, selection, and presentation to the national Variety Release Committee (VRC). The process of variety release (Fig. 1), requires that elite genotypes from IITA or NRCRI are submitted to the National Coordinated Research Project on Cassava (NCRP).

NCRP then conducts trials with these genotypes at four tiers of activities namely (a) on-station research, (b) inter-institute collaborative research, (c) multilocational testing, and (d) on-farm research. Each of these four tiers is reasonably distinct in its functioning, but the product of each strongly influences the direction of activities in all others (FAO 1984). Success of this system is conditioned by the proper

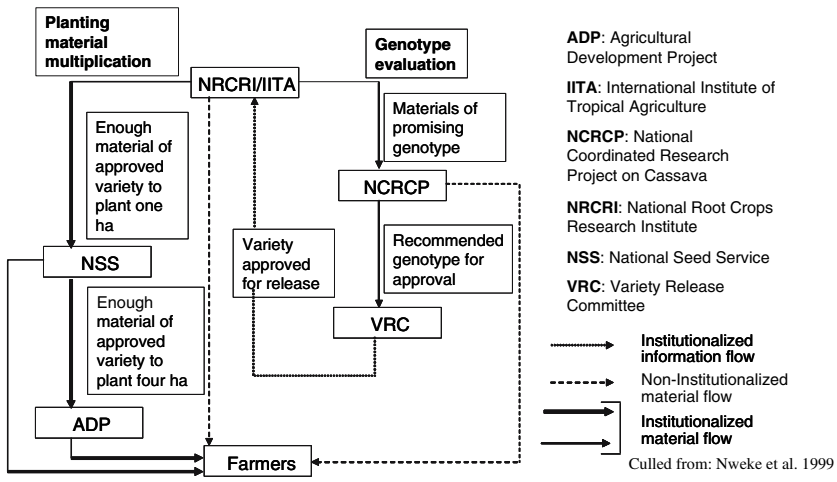


Fig. 1 Variety release process in Nigeria

harmonization of activities in the four tiers, leadership/discipline of the NCRP coordinator, and funding. During the NCRP trials some genotypes trickle into farmers' hands but data from promising genotypes are forwarded to the VRC. The national VRC officially releases genotypes after data from several years of testing, confirming their superior performance has been approved. IITA or NRCRI then pass to the National Seed Service (NSS) enough planting material of each variety to plant one hectare. Some of the materials also at this time may get to farmers from IITA or NRCRI. The NSS, on receipt of the elite genotypes, multiplies them to plant at least 4 ha of each. These will then be given to contract farmers and Agricultural Development Projects (ADPs) for further multiplication and distribution to a larger number of farmers.

Materials and methods

The ICP began fieldwork in 2003 by planting 40 new genotypes in trials with three check varieties [TMS 30572, TMS 4(2)1425, and TMS 82/00058]. The 40 genotypes were the results of a decade of genetic enhancement work at IITA in Ibadan, Nigeria. The check varieties were among the 17 genotypes earlier released (Table 1).

Considering the life span of ICP (4 years) and need to deploy as quickly as possible CMD-resistant varieties into the fields, a FTPSA was devised by ICP to meet this need and also to abide by the laws of Nigeria. The approach entails invitation of all the executing agencies involved in variety release (Ministry of Agriculture and Rural Development, ADPs, NSS, NRCRI, farmers) to participate from the onset

Table 1 Attributes of the 17 cassava varieties released to farmers for cultivation in Nigeria prior to the project

Genotype	BH	CD	EA	PDT	FRY	DMC	GY	STY	HCN
Code number	1	2	3	4	5	6	7	8	9
TMS 91934	m	s	w	m	32	34	26	21	High
TMS 90257	p	m	w	h	43	25	23	23	15.5
TMS 84537	p	m	w	h	35	28	18	27	6.3
TMS 82/00661	p	m	w	h	39	30	22	26	4.1
TMS 82/00058	**p**	**m**	**w**	**h**	**35**	**28**	**21**	**26**	**6.4**
TMS 81/00110	p	M	w	h	28	31	24	25	4.5
TMS 50395	m	M	w	m	36	29	24	12	High
TMS 4(2)1425	**m**	**p**	**sav**	**m**	**26**	**36**	**25**	**22**	**3.1**
TMS 30572	**p**	**p**	**w**	**m**	**27**	**34**	**25**	**24**	**7.5**
TMS 30555	m	p	w	m	17	32	24	20	High
TMS 30001	m	m	w	m	16	28	23	22	Low
NR 83107	p	m	w	h	22	31	22	19	High
NR 8212	p	m	w	h	27	37	25	21	High
NR 8208	p	m	w	m	26	32	25	23	High
NR 8083	p	m	w	h	31	43	36	25	High
NR 8082	p	p	w	h	32	32	22	19	High
NR 41044	m	p	for	m	37	34	25	23	High
Mean	–	–	–	–	29.94	32.00	24.12	22.24	–
Std. dev.	–	–	–	–	7.403	4.228	3.638	3.580	–
CV (%)	–	–	–	–	24.7	13.2	15.1	16.1	–

Source: Ikwelle et al. 2001. Three varieties in bold were used as checks in the selection trials

Notes: BH: branching habit (m = moderate, p = profuse); CD: canopy development (m = moderate, p = profuse, s = sparse); EA: ecological adaptation (w = wide, sav = savanna, for = forest); PDT: pest and disease tolerance (m = moderate, h = high); FRY: fresh root yield [t/ha]; DMC: dry matter content (% of fresh peeled root); GY: *gari* yield (*gari* weight as % of fresh unpeeled roots); STY: starch yield (starch weight as % of fresh unpeeled root yield); HCN: hydrocyanic acid potential in processed products (mg/100 g)

in a combined series of trials. The mandatory on-farm trials (OFTs), demonstrational trials (DEMOs), and multilocational trials (MLTs), instead of being carried out in relay, were executed concurrently for 2 years.

The OFTs were conducted by a random set of farmers in each of the cassava growing local government council areas of 12 States in southern Nigeria. The south-south States were the following, from West to East: Ondo, Edo, Delta, Bayelsa, Rivers, Akwa Ibom, and Cross River. The south-east States comprised: Anambra, Imo, Enugu, Abia, and Ebonyi. In the 2003/2004 season, 110 OFTs per State were established but this number was reduced to 66 per State in 2004/2005. The DEMOs were planted at visible points

Table 2 Locations and implementing partners for multilocational trials

SN	Location	State	2003/04 MLT manager	2004/05 MLT manager
1	Abeokuta	Ogun	–	University of Agriculture, Abeokuta
2	Ado Ekiti	Ekiti	–	IITA
3	Akure	Ondo	–	IITA
4	Awa	Akwa Ibom	–	IITA
5	Badagry	Lagos	–	IITA
6	Biase	Rivers	–	Prison farm, Biase/IITA
7	Calabar	Cross River	University of Calabar	University of Calabar
8	Egbema	Imo	Nigeria Starch Mill (NSM)	Nigeria Starch Mill (NSM)
9	Akure	Ondo	–	Federal College of Education, Akure
10	Ibadan	Oyo	IITA	IITA
11	Ibarapa	Oyo		IITA
12	Ikenne	Ogun	IITA	IITA
13	Ilesha	Osun	–	Leventis foundation farm, Ilesha
14	Ilorin	Kwara	Kwara state Agric. Dev. Programme	Kwara state Agric. Dev. Programme
15	Irrua	Oyo		IITA
16	Ishiagu	Ebonyi	NRCRI	NRCRI
17	Kubwa	Fed. Capital Territory	IITA	IITA
18	Malam madori	Kano	–	IITA
19	Mokwa	Niger	IITA	IITA
20	Nsukka	Enugu	University of Nigeria Nsukka	University of Nigeria Nsukka
21	Obrikom	Rivers	Green River Project (Nigeria AGIP Oil Company)	Green River Project (Nigeria AGIP Oil Company)
22	Onne	Rivers	IITA	IITA
23	Onne-Oku	Rivers	–	Oku farms
24	Oshogbo/Ife	Osun	Osun State Agric. Dev. Programme	–
25	Otobi	Benue	NRCRI	NRCRI
26	Sabo Ngida	Kaduna	Hill View farms	Hill View farms
27	Songhai	Delta	–	Songai Farms/IITA
28	Ubiaja	Edo	IITA	IITA
29	Umudike	Abia	NRCRI	NRCRI
30	Uyo	Akwa Ibom	University of Uyo	University of Uyo
31	Warri	Delta	SHELL Agric Demonstration Farm	SHELL Agric Demonstration Farm
32	Yenagoa	Bayelsa	–	IITA
33	Zaria	Kaduna	–	IITA

in the community so that passers-by would always see them as they went about their daily activities in the village. In each of the 12 project States there were 8 trials in 2003/2004 but the number increased to 18 in 2004/2005. The MLTs were established and managed by research technicians from IITA, national research institutes, universities, and private farms until harvest (Table 2). The agroecological zones where cassava is grown were representatively covered by the placement of the sites for this type of trial (Fig. 2). A total of 32 MLTs were established in 2004/2005 compared to 18 in 2003/2004.

There were several multiplication sites in each season to cater for the high demand for improved lines, and to have available any of the genotypes that would eventually be released. In the first year, all genotypes were included in the multiplication exercise but in the second year, only the most promising in each location were multiplied.

In OFTs, DEMOs and MLTs conducted by ICP 40 new clones were used along with three known checks (TMS 30572, TMS 4(2)1425, TMS 82/00058). These new clones, with the potential to replace the current nationally released lines, were 91/02324, 92/0057, 92/0067, 92/0325, 92/0326, 92B/00061, 92B/00068, 94/0026, 94/0039, 94/0561, 95/0166, 95/0289, 95/0379, 96/0523, 96/0603, 96/1089A, 96/1565, 96/1569, 96/1632, 96/1642, 97/0162, 97/0211, 97/2205, 97/3200, 97/4763, 97/4769, 97/4779, 98/0002, 98/0505, 98/0510, 98/0581, 98/2101, 98/2226, 99/2123, 99/3073, 99/6012, M98/0028, M98/0040, M98/0068, and TME 419.

Criteria for the choice of these 40 genotypes were as follows.

- CMD resistance/tolerance (score of <1.04 on severity scale 1–5).
- Multiple pest resistance/tolerance (score of <1.04 on severity scale 1–5; root rot, <5% incidence).

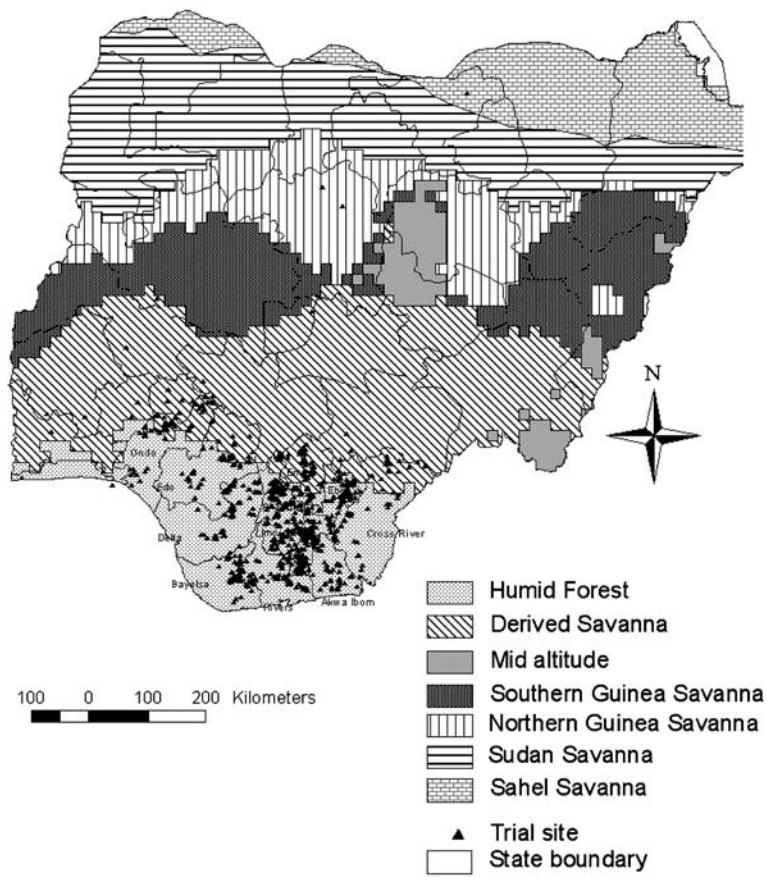


Fig. 2 Nigeria, showing agroecological zones, state boundaries, and trial sites

- High and stable yields (<11 t/ha baseline from farmers' fields, choice genotypes must have yields >20 t/ha)
- High dry matter content (>24% baseline, aim >30%).
- General feedback on acceptability from Uniform Yield Trials conducted by IITA.

For the OFTs and DEMOs**,** the aim was to get a sample of locations and sites that represents the cassava growing areas of the State. The decision on where to locate the trial sites were taken by each State team of ADP workers. The OFTs and DEMOs were spread to the three senatorial districts in each State to get a State-wide spread. This was to enable us to make State-level generalizations, based on the data retrieved from the trials.

Character variables

Harmonization meetings were convened with all implementing partners to agree on the minimum number of assessment variables that would be acquired from each of the trials as well as the method of collection. The minimum variables expected and methods of obtaining them are shown in Table 3.

Many variables were observed and noted, but, in the final analysis, some were dropped. Those considered of merit were included in the data tables on which the selection algorithm was executed. Farmers' field days were organized in each of the States to obtain data on farmers' preferences. The variables assessed were plant formation, root weight, plantable stem weight, root flesh color, root shape, *gari* quantity, *gari* color, *gari* taste, *gari* swelling capacity, *gari* hand feel, and *gari* stickiness. Assessment was done on a scale of 1–3, where 1 meant disliked and 3 meant liked.

Effective data received

At the end of harvest for both seasons, the whole volume of expected data was not received. All implementing partners were expected to send their data sheets to IITA as hard copy. No analysis was expected, only the field records as they were collected by the field workers.

The number of data entries expected per genotype in 2004/2005 was: n = (12 States [66 OFTs + 18 DEMOs]) + 32 MLTs = 1040 cases; in 2003/2004: n = (12 States [110 OFTs + 8 DEMOs]) + 18 MLTs = 1434. Any genotype that had all cases was considered to have a high information load. The percentage of the number of data entries actually available for use in data analyses is indicative of the rigor of the decisions made about the particular genotype. Because of the different soils, different agroecologies, varied dates of planting and dates of harvest, different levels of promptness with which cultural practices were applied during the growth of the cassava field, the data from each case were considered random and sufficient to represent the environment over which the genotypes were grown and to express their genetic composition. The need to relate the analyses to the functional interpretation of the data was, however, the main guiding principle.

In both OFTs and DEMOs, apart from the minimum variables agreed at the harmonization meeting, each State provided data on farmers' preferences. There were a combination of food quality characteristics, FYLD, and stem type. Data were received from all the MLTs, although some executors of MLTs did not provide all the agreed variables.

Data collation and analyses

The varied steps taken in the appreciation of the data received, required a series of software to be employed.

- Microsoft Excel: for data entry and organization
- SAS: for analysis of variance (ANOVA) and regression to extract β values for use as relative weight of character variables in the creation of selection index (SAS 2003).
- GGE Biplot: to test stability of genotypes across locations and associations among character variables and between genotypes and character variables (Yan 2001).
- ArcView: for the mapping of the sites to understand the level of coverage of the cassava growing areas of Nigeria (ESRI 1999).

A combined analysis of all OFTs/State was carried out using augmented design procedure where each set of 11 farmers constituted a complete augmented design setup. A mean of the 10 OFT locations per State in 2003/2004 and 6 OFT locations per State in 2004/2005 produced the summary of OFT/State.

Table 3 Minimum variables expected from OFTs, DEMOs, and MLTs as agreed with all implementing partners

Time	Variables	Method	OFT	DEMO	MLT
At harvest	Number of plants (NoStd)	Number of plants harvested in the four central rows.	1	1	1
At harvest	Root weight	Total weight of fresh tubers from approved harvest area.	1	1	1
At harvest	Weight of root suitable (RWSuit)	Weight of only roots suitable to be sold in local root market.	1	1	1
At harvest	Weight of root unsuitable (RWUnsuit)	Weight of root unsuitable to be sold in local root market.	1	1	1
At harvest	Number of 1 m long stems	Number of 1 m long stems that can be sold as planting material.		1	1
At harvest	Number of roots	Total count of all roots in approved harvest area.			1
Postharvest	Dry matter content (DMC)	Oven-dry 100 g of peeled roots and 100 g of peels at 80°C for 48 h or until dry and weigh.			1
Postharvest	Mealiness	Boil 2 cm thick peeled cylindrical roots for 25 min in already boiling water. Press between fingers: Score: 0 = waxy, 1 = not mealy, 2 = mealy, 3 = very mealy.			1
Postharvest	Taste	For boiled samples only. Score 1 = bitter, 2 = bland, 3 = sweet.			1
Postharvest	Fresh cotex color (CtCol_Frsh)	For fresh samples. Score 1 = white, 2 = cream, 3 = yellow.			1
Postharvest	Boiled cotex color (CtCol_Boil)	For boiled samples. Score 1 = white, 2 = cream, 3 = yellow.			1
Postharvest	Ease of peeling (Ease_peel)	Peel 5–10 roots by hand, note ease when separating peel from the cortex. Score: 1 = difficult, 2 = easy, 3 = very easy.			1
Postharvest	Knife peel loss (KnfPeelLoss)	Use team of 3–5 peelers. Peel 10 kg of fresh roots. Weigh peels and weigh cortex.			1
Postharvest	Hand peel loss (CortPeel)	Weigh roots and peels separately after hand peeling roots.			1
Postharvest	Number of root suitable (RtNoSuit)	Number of roots suitable for sale in local root market.			1
Postharvest	Number of root unsuitable (RtNoUnsuit)	Number of root unsuitable for sale in local root market.			1
Postharvest	Weight of shoots (ShtWt)	Total weight of all aboveground materials from approved harvest area.			1
At harvest	Plant height (PltHgt)	Average height of plants taken around the center of the plot (cm) at harvest.			1
At harvest	Rot number (rotNo)	Total number of rotten roots from approved harvest area.			1
At harvest	Plants with rootrot (NoPltRot)	Number of plants showing root rots at harvest.			1
At harvest	Standard stake yield (NOSTM25)	Total number of 25 cm stakes from all stems			1
Preharvest	Lodging (%Lodg)	Number of plants whose main stems are inclined more than 45 degrees from the vertical.			1
Preharvest	Cassava mosaic disease incidence (CMDI)	Proportion of plants with disease symptoms to total number of plants in approved harvest area.	1	1	1
Preharvest	Cassava mosaic disease severity (CMDS)	Severity scale 1–5, where 1 = no disease and 5 = severe damage.	1	1	1
Preharvest	Cassava bacterial blight disease incidence (CBBI)	Proportion of plants with disease symptoms to total number of plants in approved harvest area.			1
Preharvest	Cassava bacterial blight disease severity (CBBS)	Severity scale 1–5, where 1 = no disease and 5 = severe damage.			1

Table 3 continued

Time	Variables	Method	OFT	DEMO	MLT
Preharvest	Cassava anthracnose disease incidence (CADI)	Proportion of plants with disease symptoms to total number of plants in approved harvest area.			1
Preharvest	Cassava anthracnose disease severity (CADS)	Severity scale 1–5, where 1 = no disease and 5 = severe damage.			1
Preharvest	Cassava green mite incidence (CGMI)	Proportion of plants with green mite damage to total number of plants in approved harvest area.			1
Preharvest	Cassava green mite severity (CGMS)	Severity scale 1–5, where 1 = no green mite damage and 5 = severe damage.			1
Preharvest	Sprouting ability	Proportion of plants that have sprouted 4 weeks after planting.			1

Likewise a mean of the 8 DEMOs/State in 2003/2004 and 18 DEMOs/State in 2004/2005 constituted the summary of DEMOs in each State. For each MLT, the data were analyzed to obtain the mean performance of each clone per location and across locations.

Variety selection

Results from farmers assessment using variables such as root weight, plantable stem weight, *gari* quantity, plant formation, assessed on a scale of 1–3, and actual root yield measurements were used in selecting the top ten clones for OFTs and DEMOs.

Using a selection algorithm that computed an index based on dry root yield (DYLD), CMD index, combined index for other diseases, FYLD, dry matter content (DMC), establishment ability at harvest, and standard stake yield (Number of 25 cm stakes obtainable), the top 10 and 15 clones from MLTs were computed. A followup paper will show in an illustrative way how all indices were computed.

Below is the order of the selection process:

1. Top 10 clones across OFTs/State.
2. Top 10 clones per DEMOs/State.
3. Top 10 clones per State across OFTs and DEMOs.
4. Top 10 clones per MLT.
5. Top 15 clones across MLTs (National Selection).
6. Most frequent clones across step 3 and 5 above (recommended to VRC).

In both seasons, after obtaining the top 10 clones from each State (combined evaluation of OFT/State and Demo/State) and the top 15 clones from MLTs, these two lists were combined using only FREQUENCY. So if a clone appeared in the State top list and also appeared in the MLT top list, such a clone would be said to meet both farmers' and researchers' desires (Table 4). These clones are suggested for recommendation because they occurred at the top in all the several preliminary selections.

Applying the guiding principle that analyzed results must relate to functional interpretation, it was agreed that the selected varieties must be good for the farmers and the processors. In 2003/2004, to arrive at the final list, the selected clones were further assessed on the qualities as food, industrial raw materials, and livestock feed by a team of postharvest specialists (Table 5). In 2004/2005 it was agreed that the important variables of interest to the farmer was FYLD and to the processor DYLD. Fresh roots are sold by cultivators by weight. However, processors value roots for their DMC. So in 2004/2005 using GGE Biplot, the association of these selected clones to FYLD and DYLD was evaluated (Fig. 3). The selected clones were then prioritized, based on their close proximity to these traits of most interest.

At the end of each year, all results were reviewed by all stakeholders, and promising lines were submitted to the VRC.

Results

On 30 August 2005, based on the 2003/04 data evaluation, TME 419, TMS 97/2205, TMS 98/0505, TMS 98/0510, and TMS 98/0581 were presented to

Table 4 Most frequent selected clones

	2003/2004		2004/2005	
	Clone	Frequency	Clone	Frequency
1	**92B/00061**	**2**	**96/1632**	**2**
2	**96/1632**	**2**	**95/0289**	**2**
3	**97/2205**	**2**	**M98/0068**	**2**
4	**98/0505**	**2**	**97/4779**	**2**
5	**TME 419**	**2**	**96/0523**	**2**
6	91/02324	1	**92B/00061**	**2**
7	92/0057	1	**96/1089A**	**2**
8	92/0326	1	**98/0002**	**2**
9	92B/00068	1	**95/0166**	**2**
10	95/0289	1	**98/0505**	**2**
11	97/3200	1	**98/0581**	**2**
12	97/4763	1	**TME 419**	**2**
13	98/0510	1	92/0067	1
14	98/0581	1	92/0326	1
15	M98/0068	1	92B/00068	1
16			94/0026	1
17			94/0561	1
18			96/0160	1
19			96/1569	1
20			96/1642	1
21			97/0211	1
22			97/4763	1
23			98/0510	1
24			98/2101	1
25			98/2226	1
26			99/3073	1
27			M98/0040	1

Note: Clones in bold are the most frequently from the State and MLT lists

the Technical Subcommittee (TSC) on crop variety release. The TSC approved the nominations and recommended to the national VRC. The national VRC met on 1st September 2005 and favorably considered the five varieties as suitable for official release to Nigerian farmers.

The TSC on crop variety release met on the 5 December 2006 to consider another set of nine genotypes selected from 2004/2005 data evaluation. Five varieties were approved by TSC and the varieties were presented to the national VRC. This Committee approved the registration and release of the five varieties with effect from 7 December 2006.

Table 5 Postharvest consideration of top 10 genotypes from 2003/2004 trials

SN	Industrial	Food	Livestock
1	M98/0028	95/0289	97/2205
2	TME419	92/0057	M98/0040
3	97/4763	96/1632	99/6012
4	98/0505	TME419	98/0510
5	M98/0040	98/0505	96/1565
6	99/6012	97/2205	92/0325
7	96/0523	98/0581	M98/0028
8	92/0325	92/0326	TME419
9	97/2205	92B/00061	97/4763
10	M98/0068	98/0510	98/0581

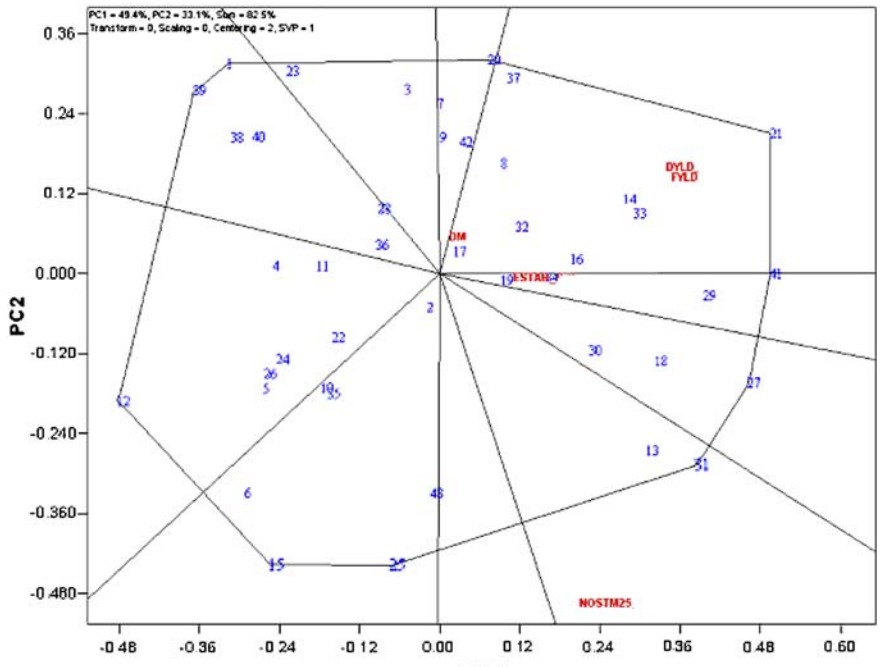
The five varieties were NR 87184, TMS 92/0057, TMS 92/0326, TMS 96/1632 and TMS 98/0002. Four of the five released lines were those of IITA; NR 87184 was a contribution from NRCRI.

The varieties released have wide adaptation in Nigeria (Tables 6 and 7). Apart from being endowed with multiple pest resistance (including CMD) the new lines were found to be suitable for food, as industrial raw material, and livestock feed. Average fresh root yields for the new lines ranged from 15.3 t/ha to 21.6 t/ha and dry matter was greater than 34% across the agroecologies of Nigeria (multilocational sites). These nine varieties are now extensively multiplied for wide distribution to Nigerian farmers to sustain cassava cultivation and preemptively manage the virulent Ugandan strain of EACMV. These lines are also forming the parent stock of all new seed entrepreneurs in Nigeria.

Lessons learnt

Some advantages were obtained using FTPSA

- Potentially good materials are already in the States and serve as a 'firewall' against CMD before the end of the selection process and end of the Project.
- Good data were available in 1 year.
- Deductions made from the first year data were enough to provisionally multiply the genotypes



Which wins where or which is best for what

Code	Clone	Code	Clone	Code	Clone	Code	Clone	Code	Clone
1	4(2)1425	11	94/0039	21	96/1632	31	98/0505	41	M98/0068
2	82/00058	12	94/0561	22	96/1642	32	98/0510	42	TME419
3	91/02324	13	95/0166	23	97/0162	33	98/0581	43	TMS30572
4	92/0057	14	95/0289	24	97/0211	34	98/2101		
5	92/0067	15	95/0379	25	97/2205	35	98/2226		
6	92/0325	16	96/0523	26	97/3200	36	99/2123		
7	92/0326	17	96/0603	27	97/4763	37	99/3073		
8	92B/00061	18	96/1089A	28	97/4769	38	99/6012		
9	92B/00068	19	96/1565	29	97/4779	39	M98/0028		
10	94/0026	20	96/1569	30	98/0002	40	M98/0040		

Fig. 3 GGE Biplot showing relative proximity of clones to FYLD and DYLD in 2004/2005 evaluation

found to be locally adapted to each of the 12 States where the Project operates and also enough for an executive release of the first five genotypes in 2004.

- This approach also provided an opportunity for the broad-based participation of experts and stakeholders from onset to finish.
- Stakeholders' participation engendered ownership and removed conflict.

Other lessons were as follows:

- There is now a great demand for these released lines, hence an important task for multiplication and distribution of released lines by NARES and other public–private stakeholders has been created.
- Monitoring of OFTs and DEMOs by ADPs was very difficult although for this case IITA was able to recover 88% of data. Extensive time was done travelling in pursuit and followup of data collation and some data arrived late.
- There were also several cases of neighborhood selection (robbery of farms) where in some trials only a particular genotype will be removed by unknown persons. These varieties were found later to produce straight stems which was a good characteristic for the new "seed enterprise" in Nigeria.
- Over 1500 farmers participated in these trials and are now local consultants to their colleagues; information on improved agronomic practices will ensure the sustainability of dissemination of the new lines.

Table 6 Attributes of nine new genotypes and three check varieties averaged over 18 MLTs, in 2003/2004 season in Nigeria

Clone	CMDSI	FYLD	DYLD	DMC	No1mstm	Gari	Starch	CNP	Sugar	Protein
4(2)1425	**0.85**	**13.77**	**5.28**	**36.17**	**19.08**	**18.41**	**75.74**	**7.52**	**4.62**	**3.77**
82/00058	**0.49**	**16.79**	**5.88**	**32.83**	**28.91**	**20.78**	**74.86**	**20.90**	**4.42**	**3.84**
92/0057	0.15	15.94	6.30	37.06	37.52	15.92	80.92	13.32	3.75	3.31
92/0326	0.64	15.28	5.58	34.42	35.84	15.41	75.00	6.80	4.65	3.07
96/1632	0.20	19.20	7.91	40.35	28.11	14.82	75.87	15.27	4.73	3.55
97/2205	0.01	17.64	6.99	37.97	37.46	14.75	80.09	9.50	4.72	3.66
98/0002	0.10	17.31	6.57	35.46	33.48	24.38	73.06	9.68	5.30	3.16
98/0505	0.12	19.81	7.31	35.32	35.40	16.94	71.95	7.74	4.51	3.96
98/0510	0.14	15.47	5.33	34.26	28.28	18.22	79.87	10.99	5.02	3.33
98/0581	0.09	19.07	6.97	35.40	36.38	16.10	78.25	11.47	5.05	3.41
TME419	0.27	16.98	6.56	37.59	36.39	25.01	77.11	11.01	4.63	2.34
TMS30572	**0.62**	**13.59**	**5.31**	**36.32**	**30.46**	**18.18**	**71.88**	**12.47**	**4.62**	**3.37**
Mean	0.31	16.74	6.33	36.10	32.28	18.24	76.22	11.39	4.67	3.40
SE	0.08	0.59	0.25	0.57	1.59	1.01	0.90	1.12	0.11	0.12
Mean across 43 clones	0.23	16.72	5.98	34.46	32.94	17.60	76.49	11.44	4.65	3.43
SE across 43 clones	0.03	0.36	0.15	0.39	0.90	0.46	0.62	0.52	0.07	0.09

Varieties in bold were used as checks in the selection trials

FYLD: fresh root yield (t/ha); DMC: dry matter content of roots (%); DYLD: dry root yield (t/ha); CMDSI: cassava mosaic disease index; Starch: starch yield (starch weight as % of fresh unpeeled root yield); CNP: hydrocyanic acid potential in processed products (mg/100 g); Dyld: dry forage yield (t/ha); No1mstm: standard bundle length (number of one meter stems from plant); *Gari*: *gari* yield (%); Sugar: root sugar content (%); Protein: root protein content (%)

- The whole process was intensive but with a shorter time to get varieties to farmers.

For the future, we will recommend from experience, fewer OFTs, more DEMOs, and more MLTs. It will be better to have teams to score across locations for better data reliability than for each site to be evaluated by different individuals. There is also the need to hire non-ADP personnel to monitor OFTs and DEMOs independent of the ADPs so that two datasets will be produced that can be used to authenticate each other. Local planting time and harvest regimes must be respected. The whole exercise was expensive, so, from the onset a realistic budget must be made. The authors, however, do not have data to compare the costs incurred from the FTPSA to costs that would have been incurred if the trials and selection were conducted in old way for 6–8 years. Since 1986, no new cassava variety has been released in Nigeria. Even those released were not registered until 10–20 years after (NACGRAB 2004) but, with the FTPSA, eight lines were released and registered over 2 years with more accurate and geographical widespread data.

Discussion

Nominating a fair number of genotypes for the Nigerian cultivator is a good process because of the suitability of one genotype in at least a site over the widely varying ecologies represented in the cassava growing areas. With the large number of options of genotypes that have superior DYLD in relation to the check varieties, cultivators will have to grow and pick out their local best from the alternatives available. The genotypes released are not all likely to be suitable for every farmer's field. Therefore, local niche matching of the genotypes for the end-use desired and also the field situations still has to be done over the years after the official release of the set of genotypes.

The decisions on which varieties are to be selected was taken jointly by Scientists and farmers with science backed results. This agrees with FAO 1984 report that stated "an approach by which Scientists abdicate their role of deciding the differences among treatments by careful experimentation, tantamounts to passing on their own indecisions to the farmers is

Table 7 Attributes of nine new genotypes and three check varieties averaged over 32 MLTs in 2004/2005 season in Nigeria

Clone	CMDSI	OthdisSI	FYLD	DYLD	DMC	Estab	Gari	Nostm25	CNP	Starch	Sugar	Protein
4(2)1425	**0.12**	**0.28**	**16.80**	**6.61**	**36.06**	**0.70**	**24.00**	**9.53**	**7.18**	**69.89**	**4.13**	**1.92**
82/00058	**0.05**	**0.36**	**19.23**	**6.45**	**32.62**	**0.76**	**26.00**	**13.45**	**17.44**	**67.97**	**5.50**	**1.90**
92/0057	0.02	0.32	15.63	6.43	38.72	0.78	26.00	12.31	8.24	69.65	5.06	1.82
92/0326	0.06	0.28	20.24	6.88	34.50	0.78		10.96	9.13	69.35	5.74	1.57
96/1632	0.01	0.25	21.59	9.29	38.89	0.82	34.00	13.32	13.73	60.80	5.69	1.99
97/2205	0.01	0.28	15.44	6.27	38.48	0.83	25.60	16.62	8.44	64.82	3.71	1.86
98/0002	0.02	0.26	20.90	6.97	34.23	0.82	24.00	14.84	6.89	73.80	4.32	1.98
98/0505	0.01	0.27	20.54	7.61	34.86	0.84	20.20	16.87	9.68	64.42	4.70	1.75
98/0510	0.02	0.28	20.01	7.48	35.45	0.69		13.18	13.92	71.18	6.82	1.58
98/0581	0.01	0.29	21.17	7.81	35.31	0.84	24.00	13.38	4.69	69.62	4.55	1.96
TME419	0.02	0.29	18.16	7.69	39.33	0.80	20.00	11.77	6.54	66.64	5.35	1.57
TMS30572	**0.08**	**0.29**	**18.02**	**6.15**	**35.45**	**0.76**	**30.00**	**15.93**	**10.42**	**66.15**	**5.37**	**1.71**
Mean	0.04	0.29	18.98	7.14	36.16	0.79	25.38	13.51	9.69	67.86	5.08	1.80
SE	0.01	0.01	0.62	0.26	0.63	0.01	1.32	0.65	1.06	1.01	0.25	0.05
Mean across 43 clones	0.0	0.3	18.5	6.9	35.1	0.8	23.9	13.1	11.0	67.6	5.4	1.8
SE across 43 clones	0.0	0.0	0.3	0.1	0.3	0.0	0.6	0.3	0.8	0.5	0.2	0.0

Varieties in bold were used as checks in the selection trials

FYLD: fresh root yield (t/ha); DMC: dry matter content of roots (%); Dyld: dry root yield (t/ha); CMDSI: cassava mosaic disease index; OthdisSI: other disease index; Starch: starch yield (starch weight as % of fresh unpeeled root yield); CNP: hydrocyanic acid potential in processed products (mg/100 g); DYLD: dry forage yield (t/ha); Nostm25: standard stake yield (number of 20–25 cm stakes); Estab: establishment and survival ability (number of harvested stands as a percentage of the number planted on day of planting); *Gari*: *gari* yield (%); Sugar: root sugar content (%); Protein: root protein content (%)

an unpardonable irresponsibility; so, should be avoided".

The release of varieties is not annual; and thus, an occasional release of a good set of genotypes implies that there has to be another release only after sufficient genetic improvement work provides another pack of genotypes. For testing to be achieved and there must be funds to execute the different types of trials. With GIS, IITA can transfer these lines to other regions without elaborate trials hence saving funds.

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References

ESRI (1999) ArcView GIS software, version 3.3. for Windows. Environmental Systems Research Institute, Inc. Copyright © 1992–2002

FAO (1984) Food and Agriculture Organization of the United Nations. Nationally Coordinated Research Projects. Consultancy report of S.V.S. Shastry, 28 pp

Ikwelle MC, Ezulike TO, Eke-Okoro ON (2001) The contribution of root and tuber crops to the Nigeria economy. In: Akoroda MO (ed) Proceedings of 8th symposium of the international society of tropical root crops—Africa Branch. IITA, Ibadan, Nigeria

NACGRAB (2004) Crop varieties released and registered in Nigeria. National Centre for Genetic Resources and Biotechnology Moor Plantation, Ibadan, 40 pp

Nweke FI, Ugwu BO, Dixon AGO, Asadu CLA, Ajobo O (1999) Cassava production in Nigeria: a function of farmer access to markets and to improved production and processing technologies, COSCA working Paper No. 20, IITA, Ibadan, Nigeria

Ogbe FO, Dixon AGO, Hughes Jd'A, Alabi F, Okechukwu RU (2002) The status of cassava mosaic disease, cassava begomoviruses and whitefly vector populations in Nigeria. Internal technical report, IITA, Ibadan, Nigeria

SAS (2003) SAS/STAT software, version 9.1. for Windows. Copyright © 2002–2003 by SAS Institute Inc., Cary, NC, USA. Licensed to International Institute of Tropical Agriculture (IITA)

Yan W (2001) GGEBiplot-a Windows application for graphical analysis of multi-environment trial data and other types of two-way data. Agron J 93:1111–1118