IITA Transforming African Agriculture 50 1967 - 2017

NATIONAL ROOT CROPS RESEARCH INSTITUTE NRCRI UMUDIKE

ROOTS, TUBERS AND BANANAS

Overview of the Cassava Monitoring Survey in Nigeria (CMS)

Victor Manyong and the CMS Team

(Tesfamicheal Wossen, Gezahegn Tessema, Tahirou Abdoulaye, Rabbi Ismail, J. Bentley, Olanrewaju Adetunji, B. Ayedun, Arega Alene, Shiferaw Feleke, Peter Kulakow, Godwin Asumugha, M. Tokula, Abass Adebayo)

March 27, 2017

Outline

- Background of the CMS
- Components of the CMS
- Design of the CMS
- Data collection process

Background of the CMS project (why?)

Introduction

- Significant investment by IITA, NRCRI and others since the late 1970s:
  - **More than 40 cassava varieties were developed and released in Nigeria (NACGRAB, 2017).**
- Yet, adoption rates are not well documented
- How can we justify investment on crop genetic improvement?

Research Questions

Three groups of research questions

==➔ 3 presentations

Research questions

- Using DNA fingerprinting:
  - What are the cassava cultivars found in farmers fields: improved varieties or not?

=====➔ Presentation by Dr Rabbi Ismail

Research questions

- Using DNA fingerprinting:
  - What are the cassava cultivars found in farmers fields: improved varieties or not?
- Using household survey:
  - What are the levels of adoption of improved cassava varieties?
  - What are the factors driving adoption and dis-adoption of improved varieties of cassava?

===➔ Presentation by Dr Tesfamicheal Wossen

Research questions

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- Using household survey:
  - What are the levels of adoption of improved cassava varieties?
  - What are the factors driving adoption and dis-adoption of improved varieties of cassava?
- Using household survey and village level qualitative FGD:
  - What are the preferences of different end users for varietal attributes in terms of production, processing, and consumption traits?
  - Are there gender differences associated with varietal adoption, preferences, and adoption pathways?

==➔ Presentation by Dr Tahirou Abdoulaye

Research questions

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CMS Key Question:

- What factors are inhibiting the uptake of improved cultivars of cassava in Nigeria?

Components of CMS

i. Large-scale household (HH) survey using rigourous approaches and e-survey tools

ii. DNA-based varietal identification using single nucleotide polymorphism (SNP)

iii. GPS-assisted area measurement

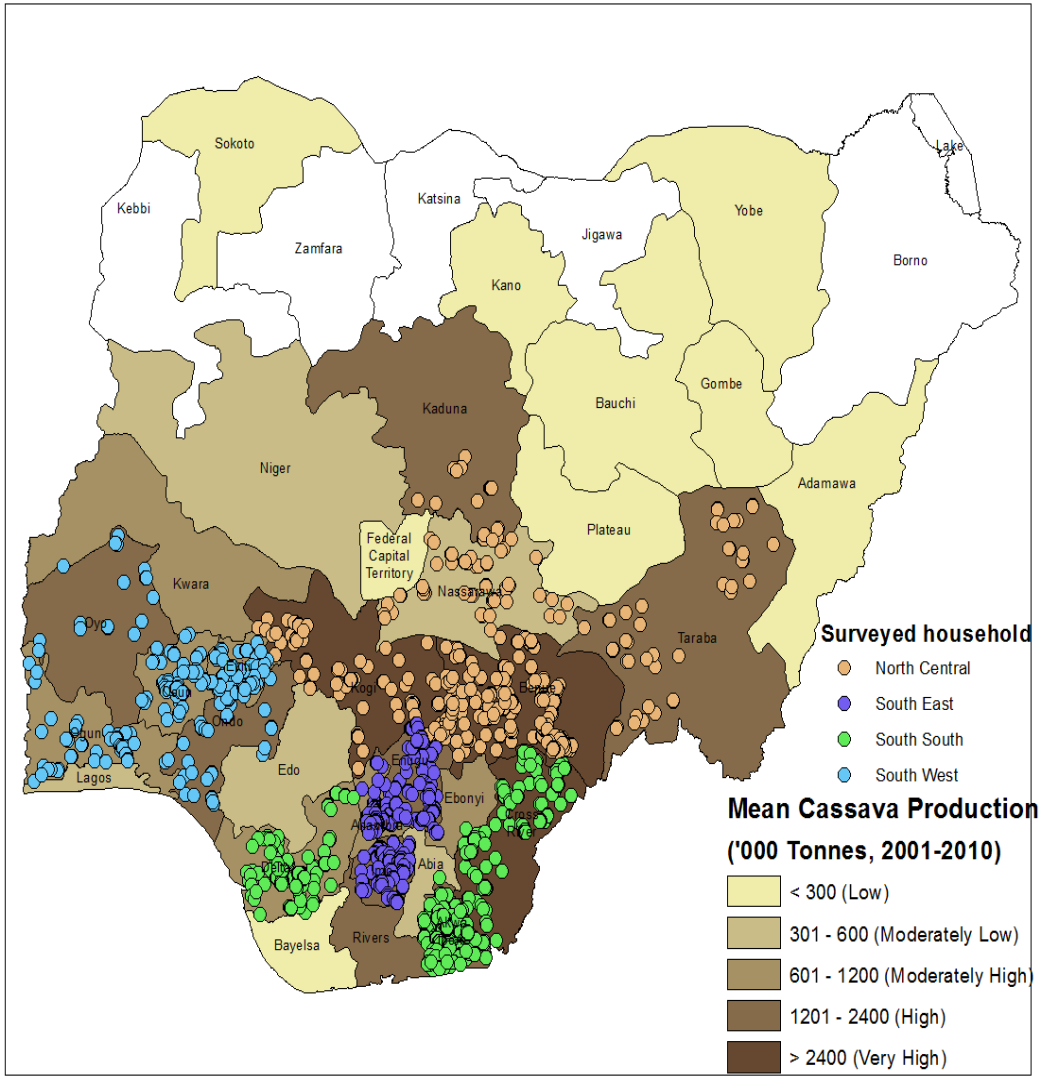
iv. Gender-differentiated end-user surveys on varietal and trait preferences.

Design meeting

- The Nigeria Cassava Monitoring Convening Workshop was organized, 15–21 March 2015 by BMGF in Dar es Salaam
- Involved: economists, biotechnology, breeders, gender experts, agronomists, extensionist, post-harvest specialist
- Institutions involved: IITA, NRCRI, CIAT, CRP-RTB (CIP), CRS, BMGF
- Key inputs on the sampling design, HH survey instrument and e-survey, process of DNA-fingerprinting, FGD, and GPS-based area measurement issues

Sampling design

- **16 States**: over 80% of cassava production stratified into **4 Regions**
- **2500** randomly selected households **~5000** plots
- **30%** of Spouses were also interviewed
- Gender-differentiated end-uses survey: **Focus group discussion** on sub-sample of randomly selected villages
- About **7428** different leaf samples for DNA extraction



Details on study regions

i. **South-West** (Oyo, Ogun, Ondo, Ekiti and Osun States)

ii. **South-East** (Enugu, Imo and Anambra States)

iii. **South-South** (Cross River, Akwa-Ibom and Delta States)

iv. **North** (Kogi, Kaduna, Benue, Taraba and Nassarawa States)

Data collection process

Recruitment of enumerators (BSc and MSc)

Data collection process

Training of enumerators

Classroom

Rural area

Data collection process

Pre-testing of survey instruments and approaches

DNA: leaf collection

GPS: area measurement

Dissemination of Findings

Manuals and Monographs

i. The cassava monitoring survey in Nigeria. Monograph, IITA, Ibadan (http://bit.ly/2n8KUrF)
ii. Cassava farmers' preferences for varieties and seed dissemination system in Nigeria: Gender and regional perspectives. Monograph, IITA, Ibadan (http://bit.ly/2mHHcdj)
iii. A manual for large-scale sample collection, preservation, tracking, DNA extraction, and variety identification analysis. IITA, Ibadan (http://bit.ly/2nEvbUY)

Conference presentation in Tanzania: ISRTC-AB (early March 2017)

i. Adoption of improved cassava varieties and impacts on productivity and poverty in Nigeria.
ii. Gender and regional-based evaluation of cassava seed sourcing and varietal traits preferences in Nigeria.

***Peer* reviewed papers**

i. Impacts of extension access and cooperative membership on technology adoption and household welfare***: Journal of rural studies (R&R)***
ii. Measuring the Productivity Impacts of Technology Adoption in the Presence of Misclassification. **American Journal of Agricultural Economics. Under review**
iii. DNA based assessment of landscape diversity of cassava varieties in Nigeria: **Draft**

DNA fingerprint-based variety identification in adoption and impact assessment – CMS project

Ismail Rabbi & the CMS Team

March 2017

CORNELL UNIVERSITY
INSTITUTE OF BIOTECHNOLOGY

Genotyping team

GEZAHEGN GIRMA TESSEMA
POST-DOC FELLOW

FEMI ALABA
RUTH UWUGIEREN

SAMPLE PREPARATION &
DNA EXTRACTION

CORNELL UNIVERSITY
PUNA RAMU
GUILLAUME BAUCHET

BIOINFORMATICS -
Raw sequences to SNP data-frame

Variety identification options

- Secondary sources (e.g. published reports)
- Seed multiplication and sales data
- Expert opinion and key informant interviews
- Community level surveys
- Farmer elicitation

- Cons: such methods have inherent uncertainty levels and often estimates have wide confidence intervals
- Alternative: DNA fingerprinting

First pilot study – cassava

Rabbi *et al. BMC Genetics* (2015) 16:115
DOI 10.1186/s12863-015-0273-1

BMC Genetics

RESEARCH ARTICLE Open Access

Tracking crop varieties using genotyping-by-sequencing markers: a case study using cassava (*Manihot esculenta* Crantz)

Ismail Y. Rabbi[1*], Peter A. Kulakow[1], Joseph A. Manu-Aduening[2], Ansong A. Dankyi[3], James Y. Asibuo[2], Elizabeth Y. Parkes[1], Tahirou Abdoulaye[1], Gezahegn Girma[1], Melaku A. Gedil[1], Punna Ramu[4], Byron Reyes[5] and Mywish K. Maredia[6]

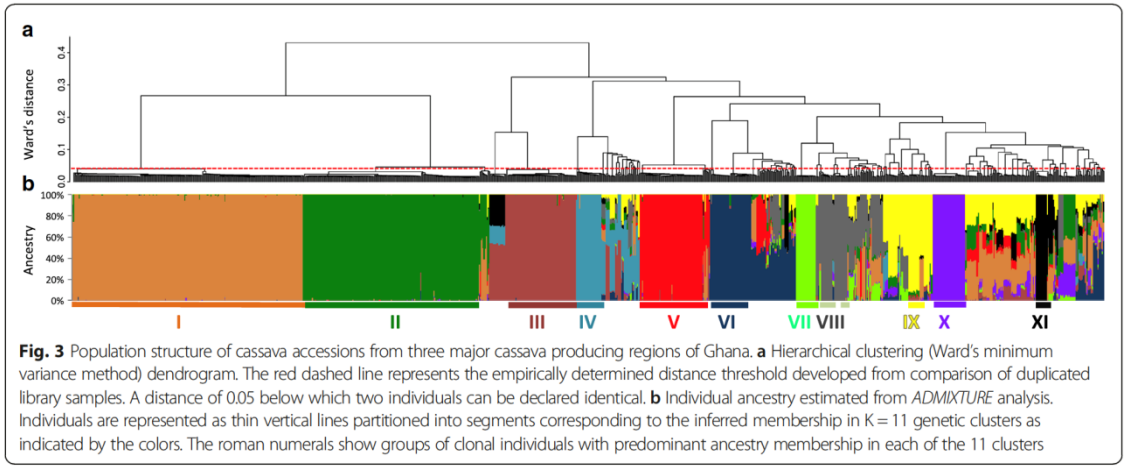


Fig. 3 Population structure of cassava accessions from three major cassava producing regions of Ghana. **a** Hierarchical clustering (Ward's minimum variance method) dendrogram. The red dashed line represents the empirically determined distance threshold developed from comparison of duplicated library samples. A distance of 0.05 below which two individuals can be declared identical. **b** Individual ancestry estimated from *ADMIXTURE* analysis. Individuals are represented as thin vertical lines partitioned into segments corresponding to the inferred membership in K = 11 genetic clusters as indicated by the colors. The roman numerals show groups of clonal individuals with predominant ancestry membership in each of the 11 clusters

Advantages of DNA markers

- DNA markers are more abundant than morphological descriptors.
- DNA is independent of environment conditions or plant growth stage.
- Caveat: Results are as good as the quality of the "reference library"
- **Reference library:**
  - A collection of **known improved/released varieties** and **landraces**.
  - All accessions from survey are matched to the reference library
  - The quality of the reference library (genotype traceability and comprehensiveness) determines your "level of success" in variety identification

DNA fingerprinting workflow

1. Field to lab sample collection, preservation and tracking
2. High-throughput DNA extraction
3. Genotyping and bioinformatics
4. Cluster analysis and matching to reference library
5. Cultivar identification and estimation of adoption rates

HH Field Lab

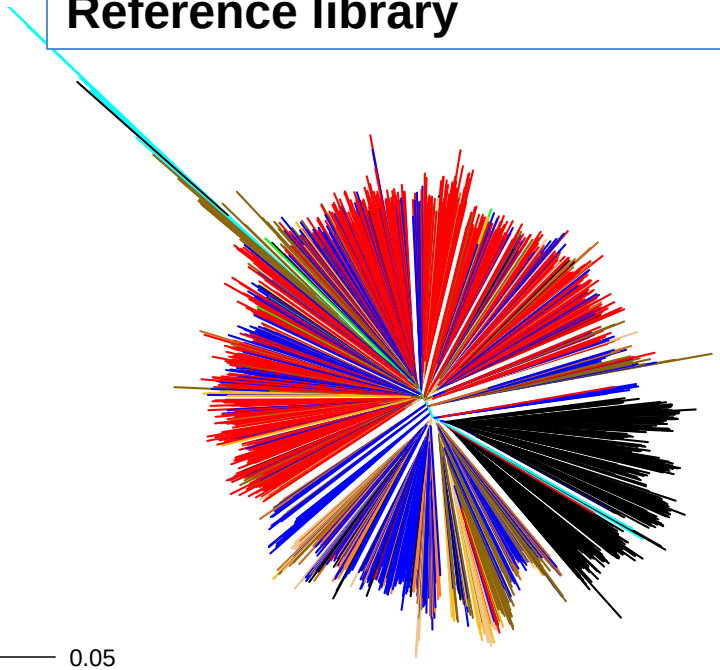
Published a monograph detailing DNA fingerprinting process

Genotyped HH samples + library

HH survey samples

Sample source	Batch 1	Batch 2	Batch 3	Total
R1(North)	497	931	568	1996
R2(SW)	758	921	96	1775
R3(SE)	1253	1	386	1740
R4(SS)	342	967	608	1917
Overall	2850	2820	1658	7428

Reference library

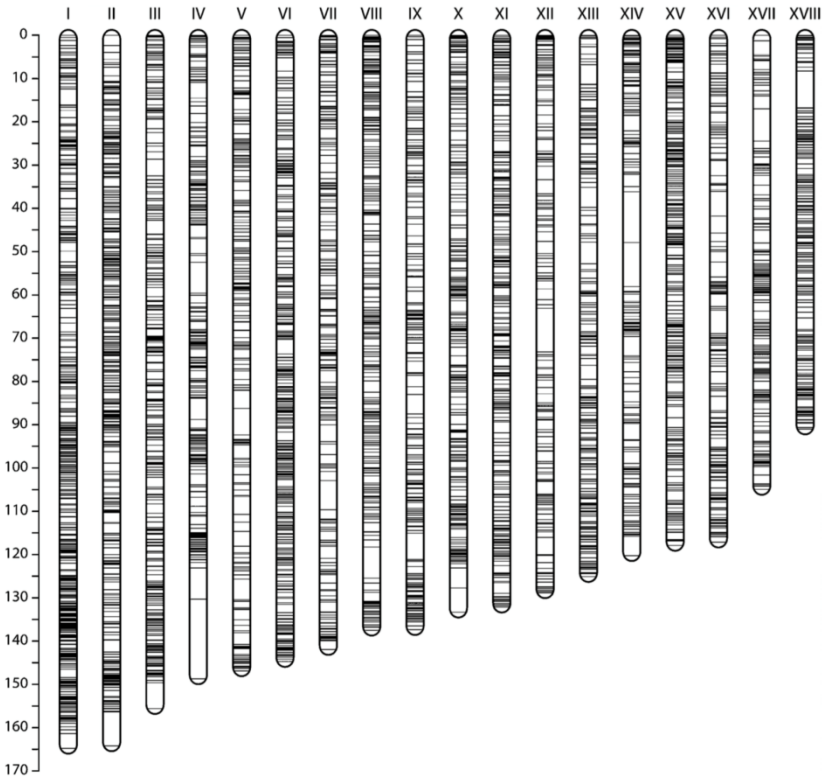


- **Reference library (n = 3891) for CMS already existed.**
- **Work done as part of previous Africa-wide cassava genetic diversity study project.**

Legend:
Wild cassava (*Manihot glaziovii*)
Genetic Gain (TMS varieties)
Germplasm collection
Regional Breeding Program collection
Latin America collection (CIAT)

Genotyping results

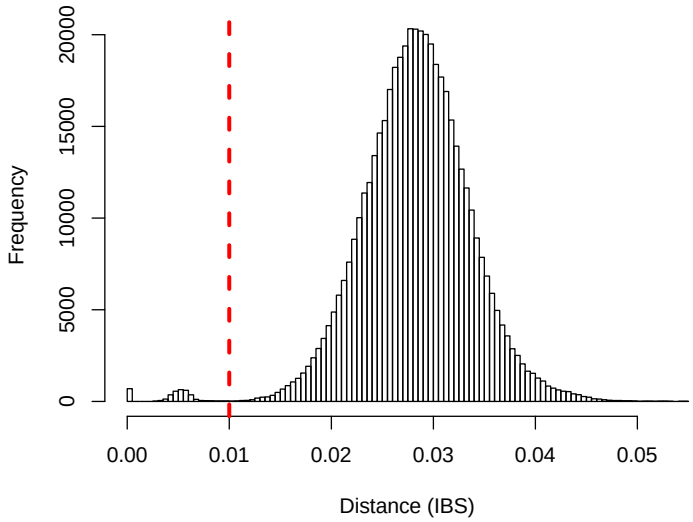
- **>11000** accessions
  - 3891 Reference Library
  - 7428 CMS Samples
- Each accession genotyped across **62548** SNP positions
- QC by **missing rates**
  - maximum per-variant == 0.6
  - maximum per-sample == 0.8
- Final data
  - **52,899** variants and **11,319** accessions passed QC filters.

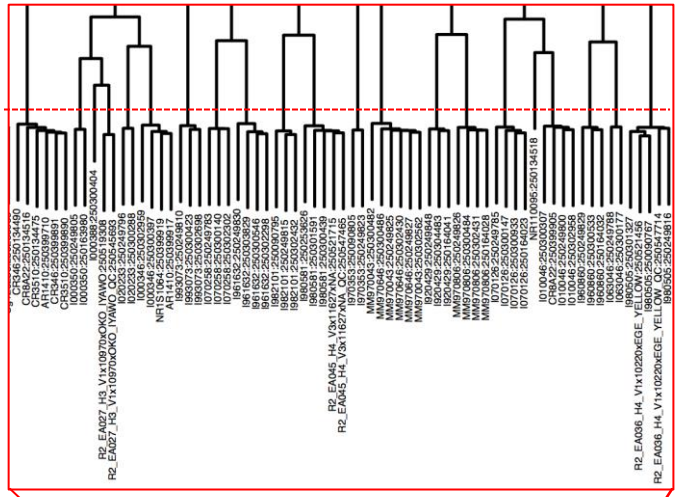


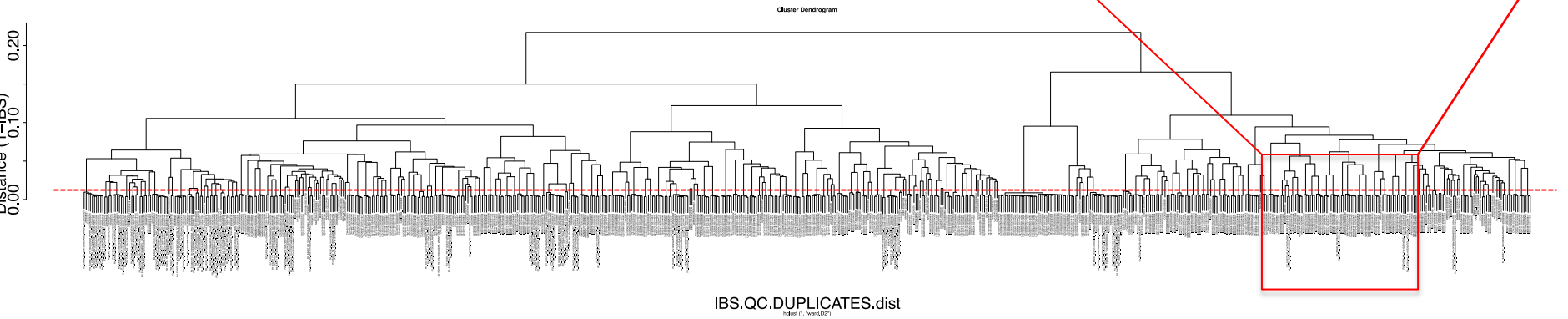
SNV markers distributed across the cassava reference genome (18 chromosomes) **ICGMC 2016**
http://g3journal.org/cgi/doi/10.1534/g3.114.015008

Distance threshold for identification for matching clones to the reference

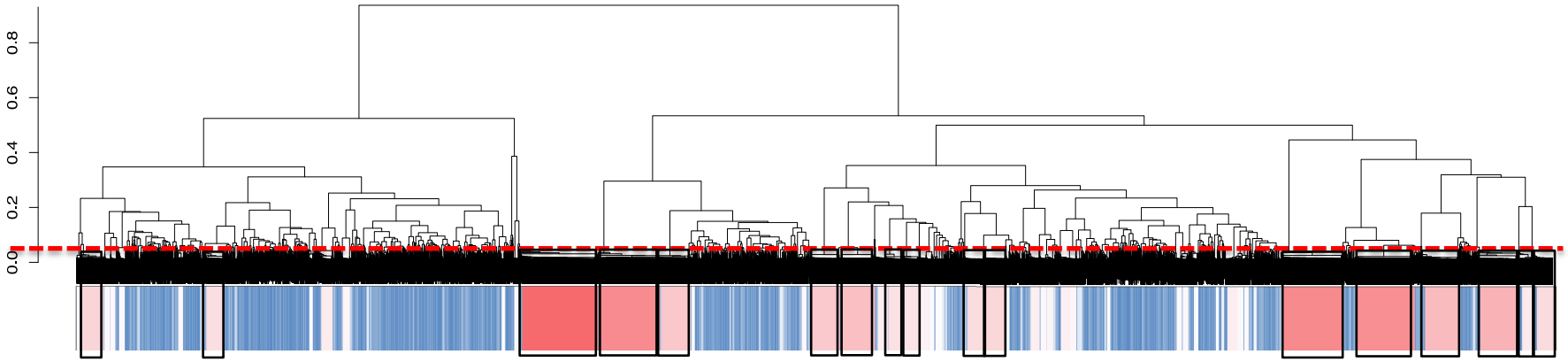
502 clones redundantly genotyped:
4x = 32
3x = 132
2x = 338

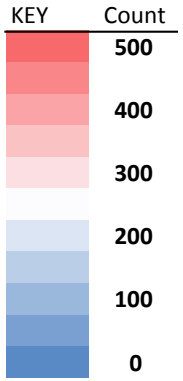






Major varieties and their frequencies

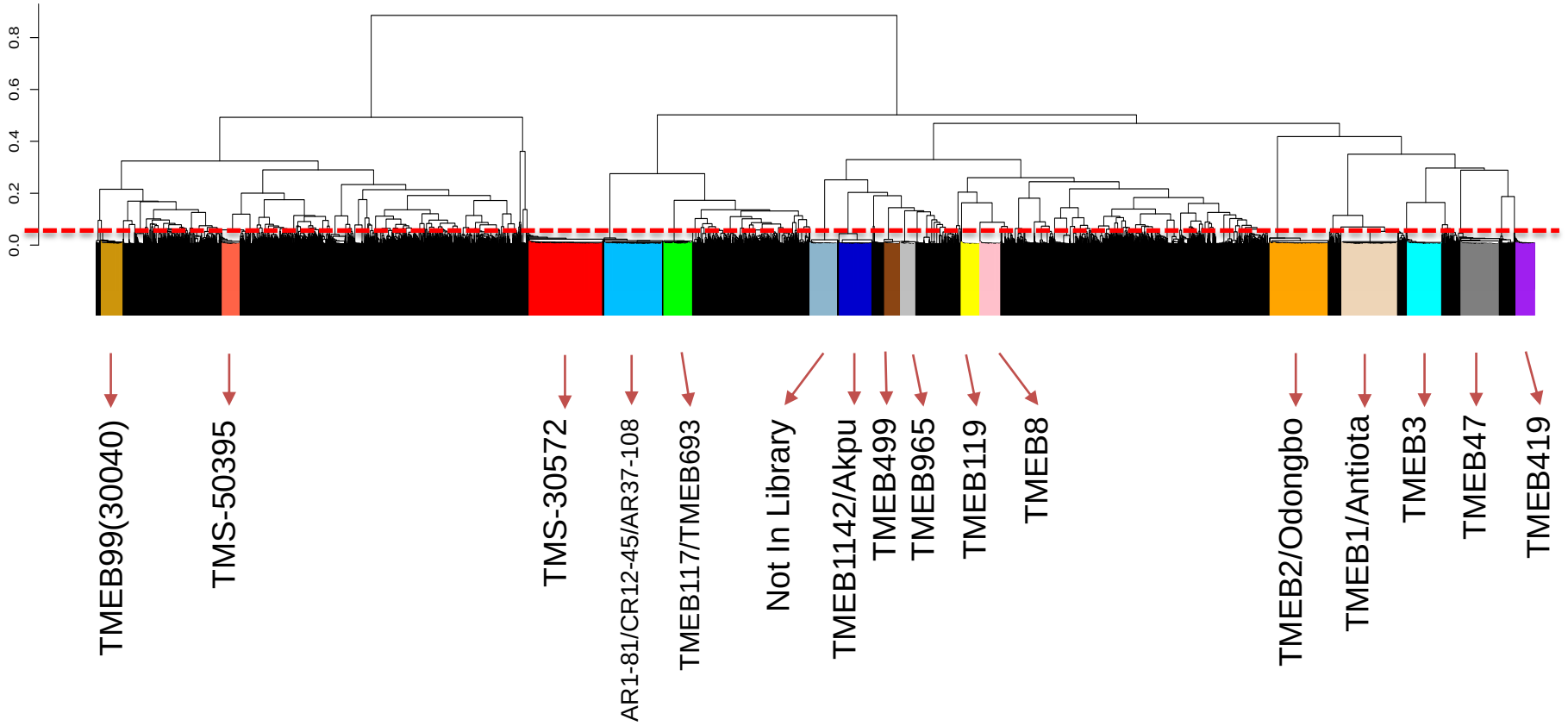




- Hierarchical cluster dendrogram of > 11 K accessions. The red line indicates distance threshold for identical sets of accessions.
- Heatmap below shows the frequencies of each set of identical clones (high = red, low = blue)

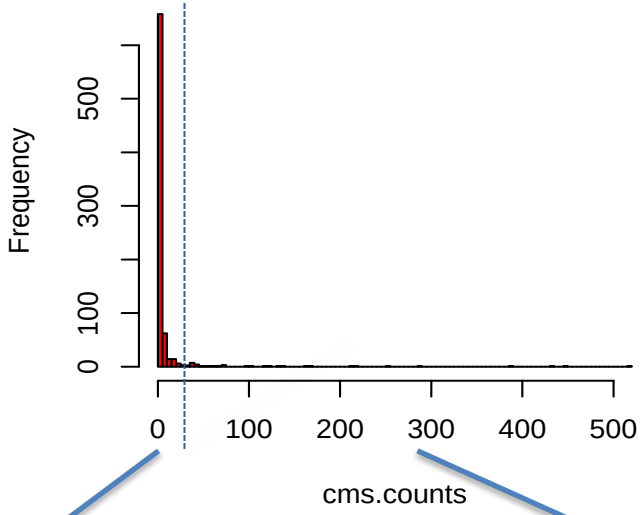
What are the major varieties ?

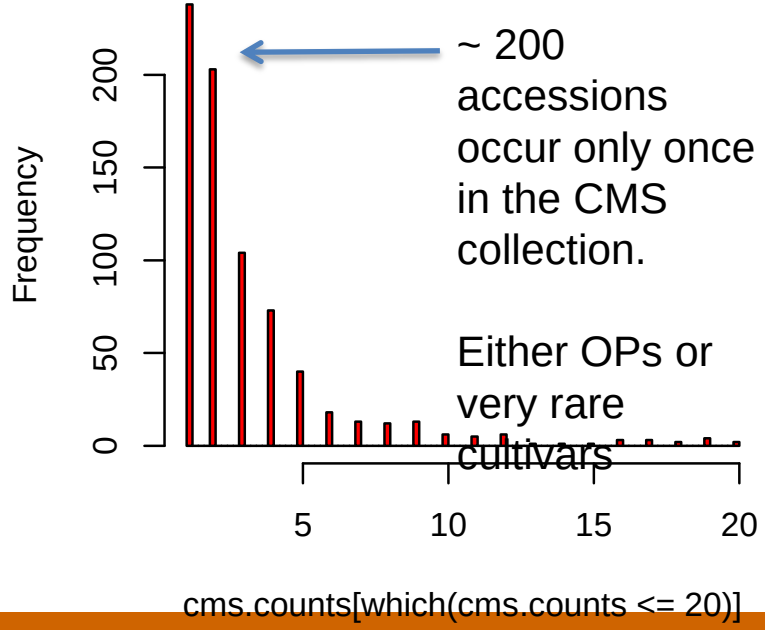
(frequency >= 100)



Major and minor cultivar groups

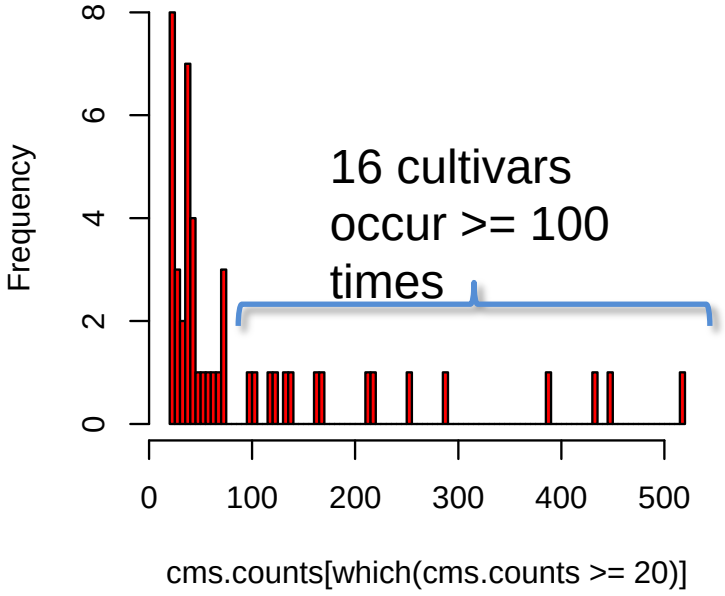
Rare clones ←→ Common clones





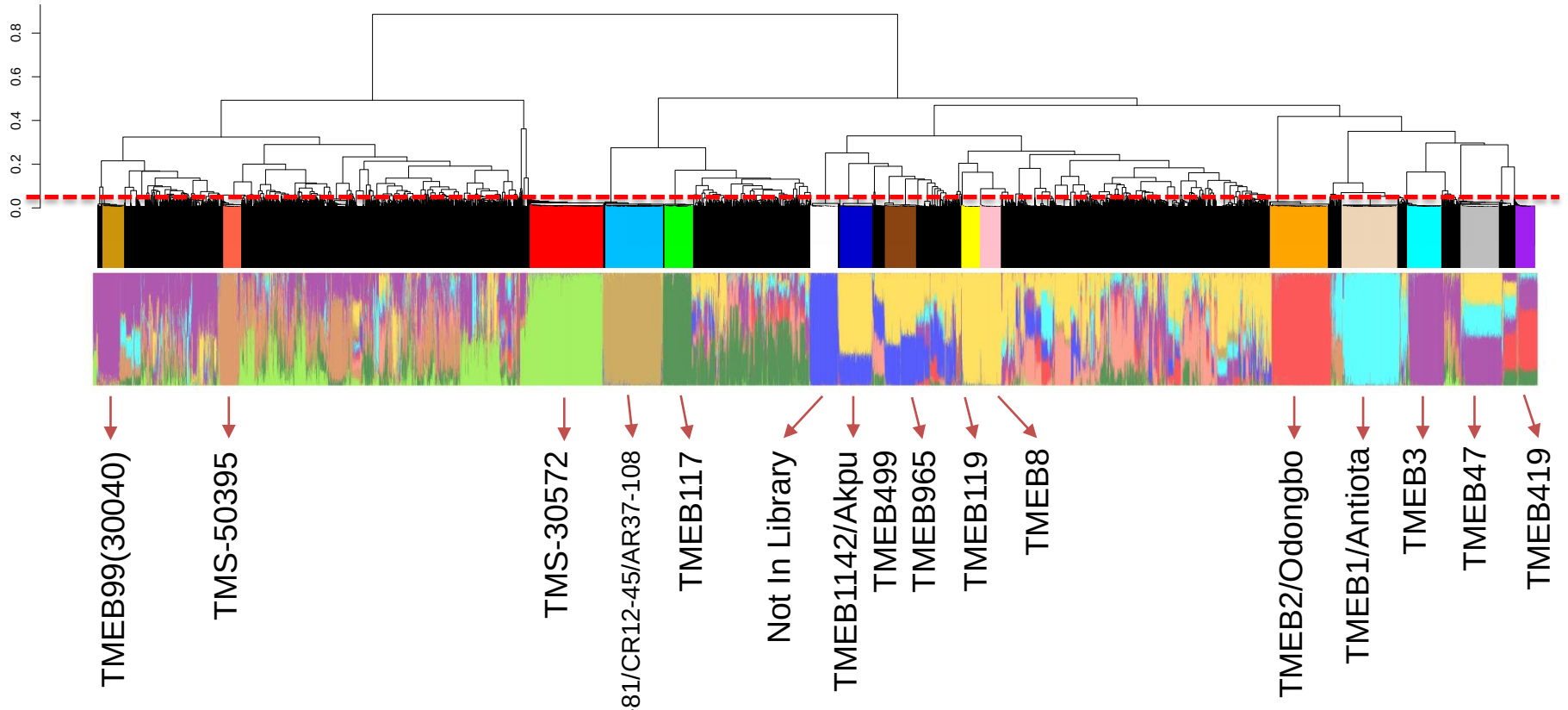
~ 200 accessions occur only once in the CMS collection.

Either OPs or very rare cultivars

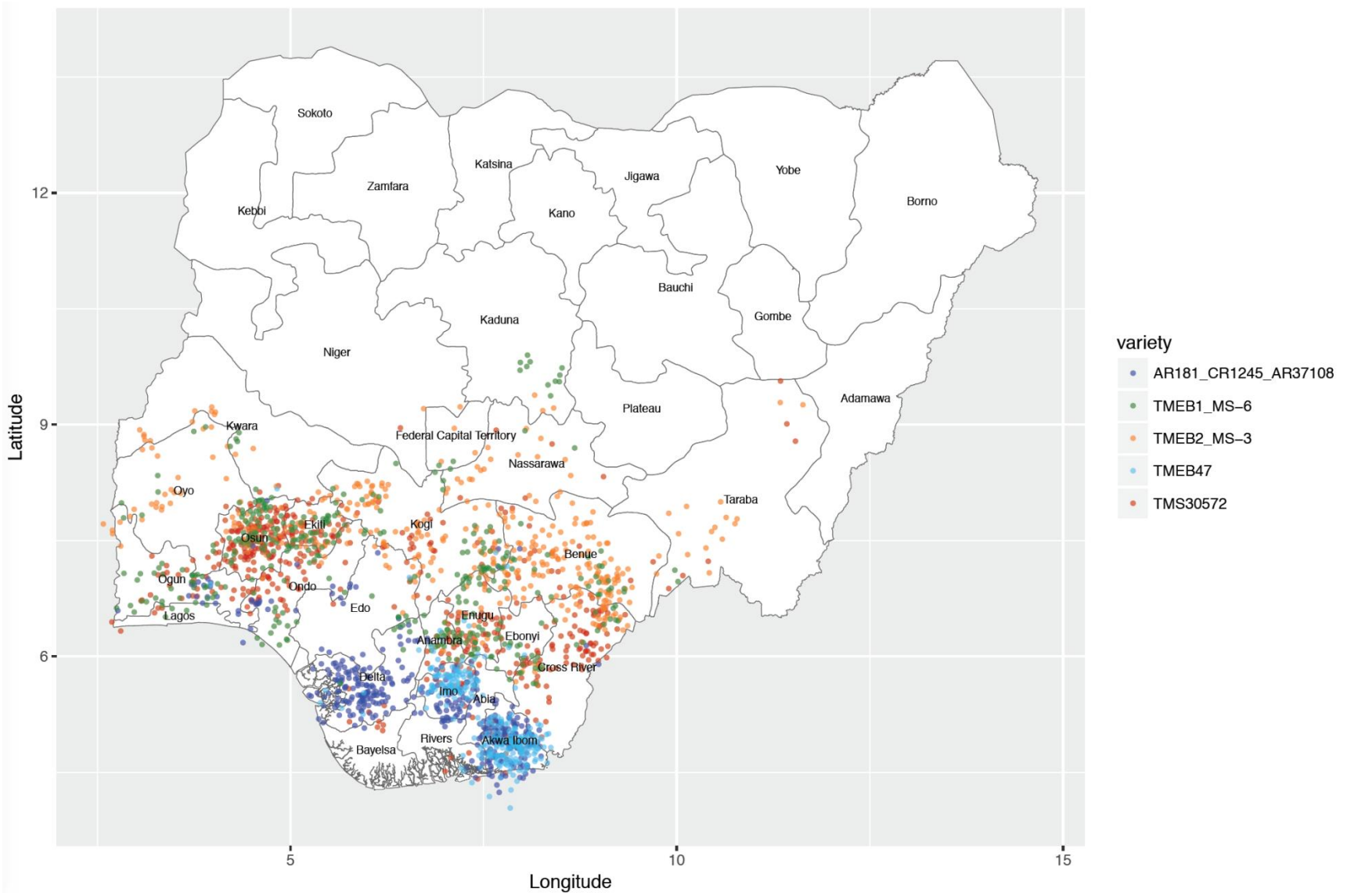


16 cultivars occur >= 100 times

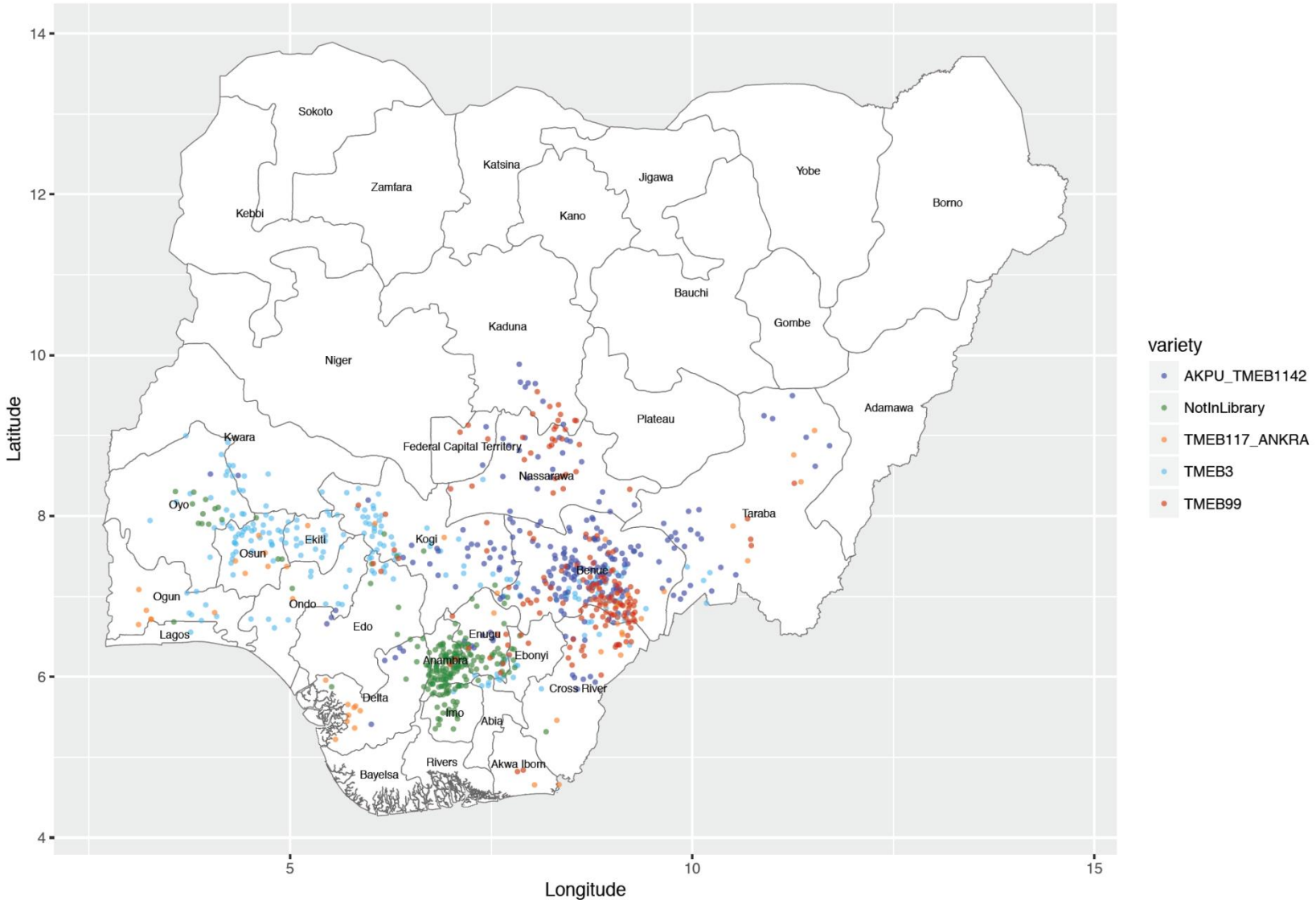
Ancestry of the studied accessions



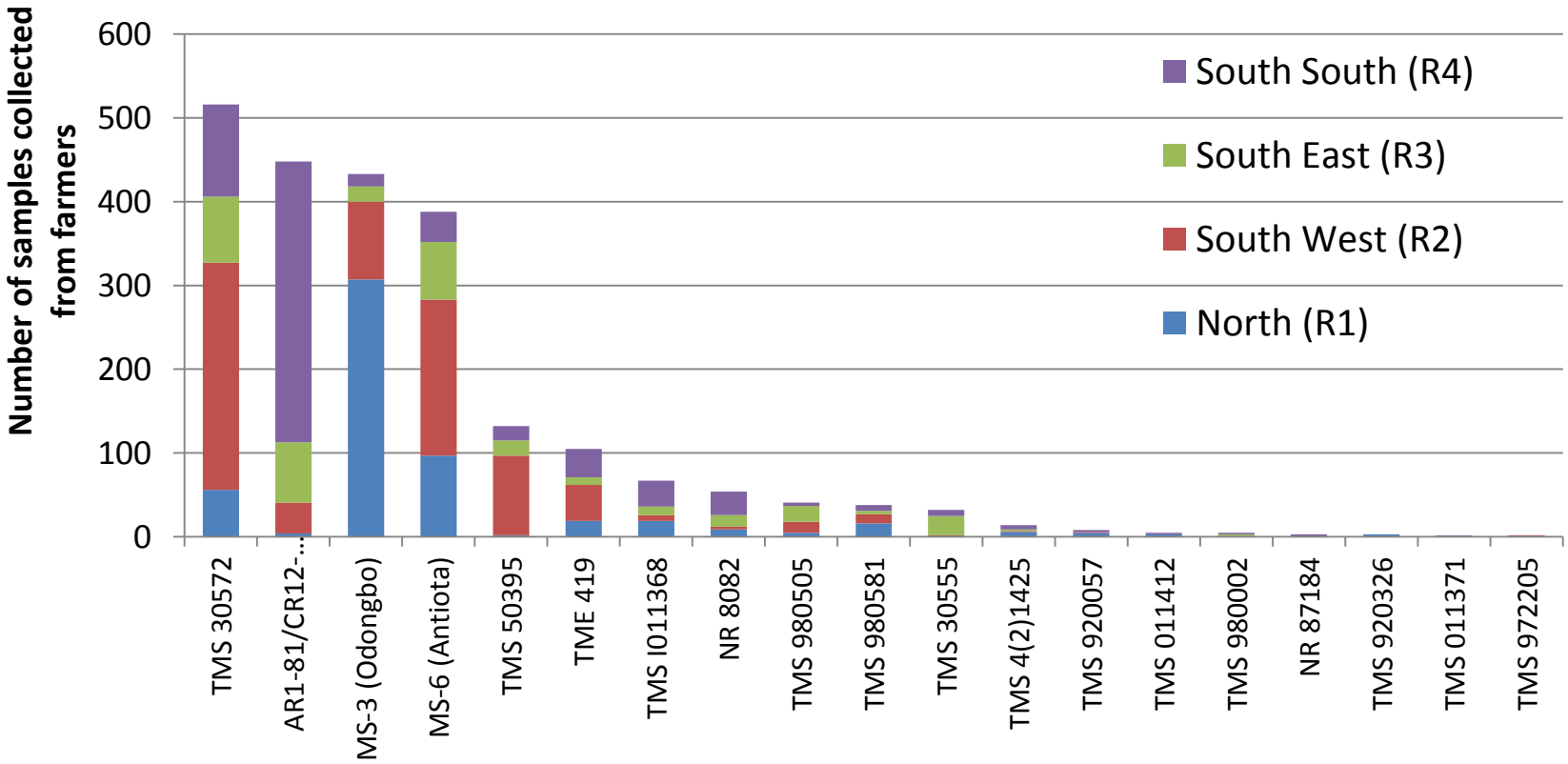
Distribution of top five varieties



Distribution of top 6-10 varieties



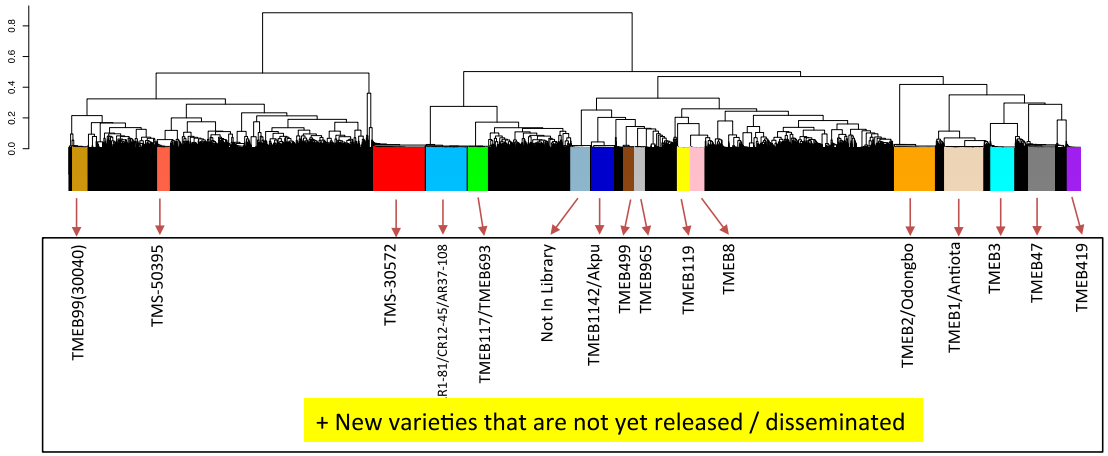
Number of samples matching released varieties

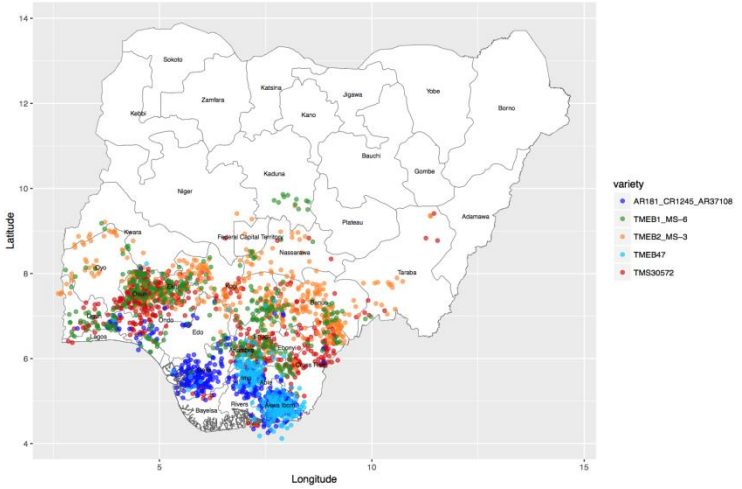


What about the other released varieties?

TMS-30572 (Idi-Oshe)	Found In CMS	TMS 82/00058	Only In Library	TMS-90257	Not In Library
TMS-4(2)-1425	Found In CMS	NR 8212	Only In Library	TMS-84537	Not In Library
MS-6 (Antiota)	Found In CMS	TMS-30001	Not In Library	TMS-82/00661	Not In Library
MS-3 (Odongbo)	Found In CMS	TMS 91934	Only In Library	TMS-81/00110	Not In Library
TMS-30555	Found In CMS	TMS 98/0510	Only In Library	NR-8208	Not In Library
NR-8082	Found In CMS	TMS 96/1632	Only In Library	NR-8083	Not In Library
TMS-50395	Found In CMS	NR 93/0199	Only In Library	NR-83107	Not In Library
TME-419	Found In CMS	TMS 96/1089A	Only In Library	NR-41044	Not In Library
TMS 97/2205	Found In CMS	NR 01/0004	Only In Library	NR 03/0155	Not In Library
TMS 98/0505	Found In CMS	CR 41-10	Only In Library	NR 07/0220	Not In Library
TMS 98/0581	Found In CMS	TMS 01/0040	Only In Library		
NR 87184	Found In CMS	TMS 00/0203	Only In Library		
TMS 92/0057	Found In CMS	NR 03/0211	Only In Library		
TMS 92/0326	Found In CMS	CR 36-5	Only In Library		
TMS 98/0002	Found In CMS	TMS 98/2132	Only In Library		
TMS 10/11368	Found In CMS	TMS 01/1206	Only In Library		
TMS 10/11412	Found In CMS	TMS 07/0593	Only In Library		
TMS 10/11371	Found In CMS	TMS 07/0539	Only In Library		

Conclusion and possible follow-up



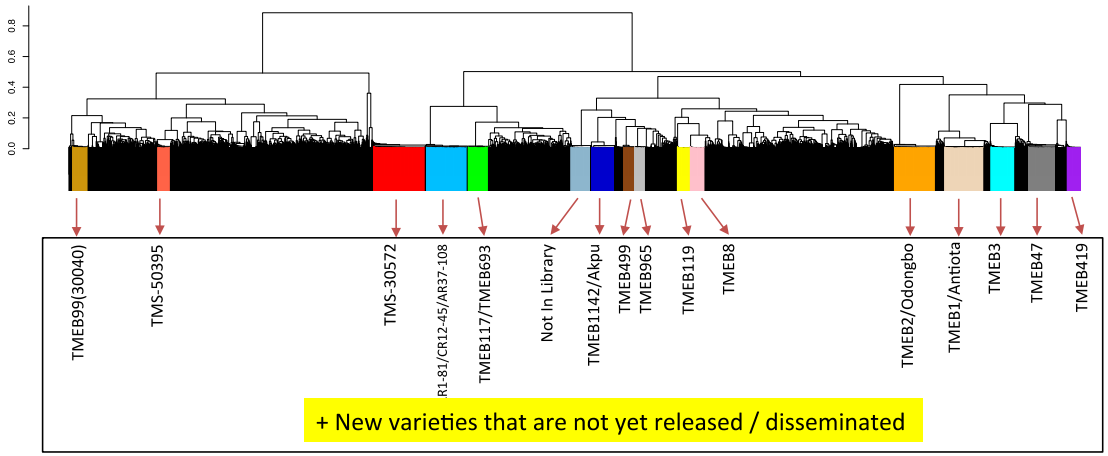


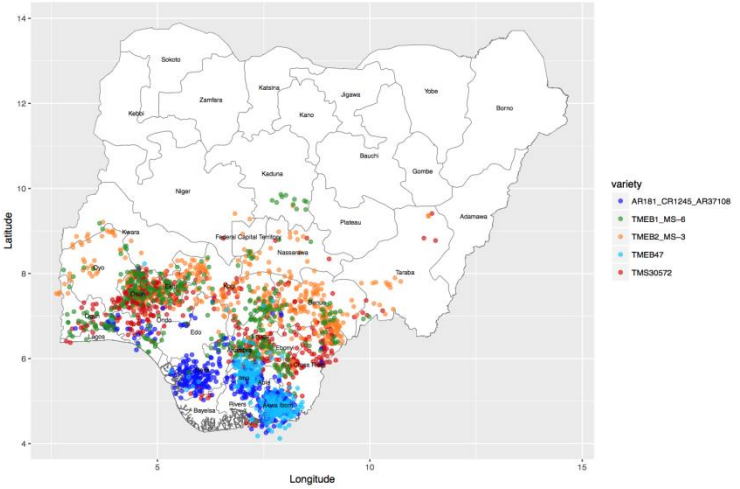
We have good data on varieties cultivated (frequencies of various clones, regional distribution, adoption rates of released/improved varieties)

Questions:

- What explains the frequencies and distribution of the varieties?
  - Why are certain varieties more common/wide-spread?
  - On the contrary, why are many of the released varieties not adopted found in farmers fields?
- Did the newly released varieties benefit from any multiplication and dissemination?
- What are the implications for breeding priorities and seed systems:
  - Genotype x Environment?
  - End use preference heterogeneity?

Conclusion and possible follow-up





- Next steps:
  - **On-farm and on-station head-to-head performance trials of:**
    - **Major cultivars**
    - **New, but yet to be released varieties**
  - Evaluate for productivity, processing and consumption traits and rank the clones according to farmer preferences.
  - Assess physical properties that underlie farmer preferences
  - Establish rigorous breeding targets.
  - Inform variety dissemination/seed systems.

Thank you

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ROOTS, TUBERS AND BANANAS

CMS: Key Results From the Household Survey

Tesfamicheal Wossen & the CMS team

March, 2017

Outline

- Introduction
- Characteristics of cassava producers
- Adoption rates
- Determinants of adoption & dis-adoption
- Implications for seed system

Motivation &research questions

- **Motivation:** Significant investment, yet adoption rates are not well documented
- Using household survey and DNA fingerprinting:
  - What is the extent of adoption of improved cassava varieties in Nigeria?
  - What are the factors driving adoption and dis-adoption of improved cassava varieties?
    - Is lack of planting materials a constraint?

Characteristics of cassava producers

Utilization of cassava

Cassava is the source of livelihood

1) Main source of **food** and **cash**

	Full sample (%)
Sales	52.9
Home consumption	38.0
For gifts	9.1

2) For 75% of cassava producers, more than 50% of their cash income comes from cassava

Extension and Credit

3) Access to credit and extension

	Full sample (%)
Credit access for cassava production	23.6
Contact with extension agents	29
Advice on cassava production	16

Membership to association

4) Significant interaction through social networks

Associations	Membership (%)
Religious group	85
Mutual Aid group	36.8
Credit and savings group	32.6
Cooperative	25.0
Cassava growers association	20.1

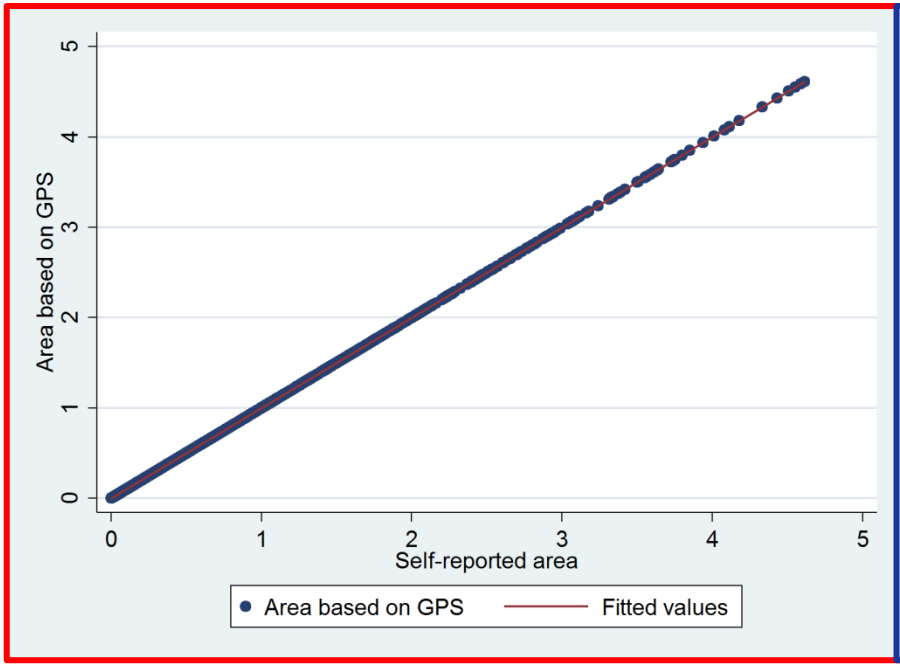
Use of other inputs

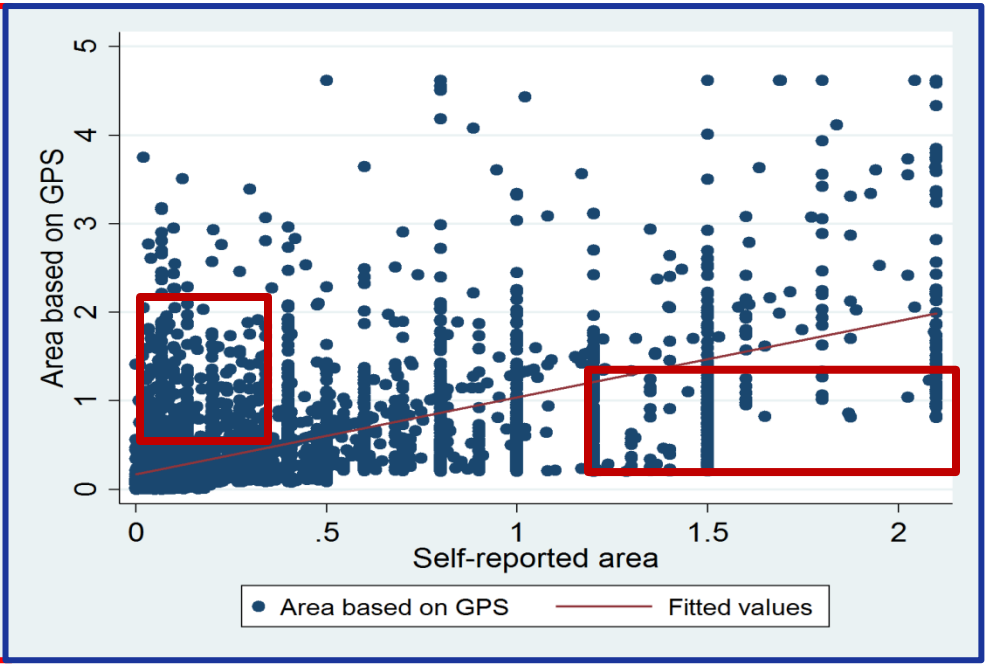
5) Usage rate of other key inputs in cassava-based system

	Full sample
NPK use (%)	32
Urea use (%)	9
Herbicide (%)	49
Pesticide use (%)	8
Manure use (%)	18

Cassava land

6) Farmers are small: mean area GPS=0.9 ha, median area GPS =0.6 ha, mean area self-reported=0.7 ha, median area self-reported =0.5 ha





Expected relationship

Observed relationship

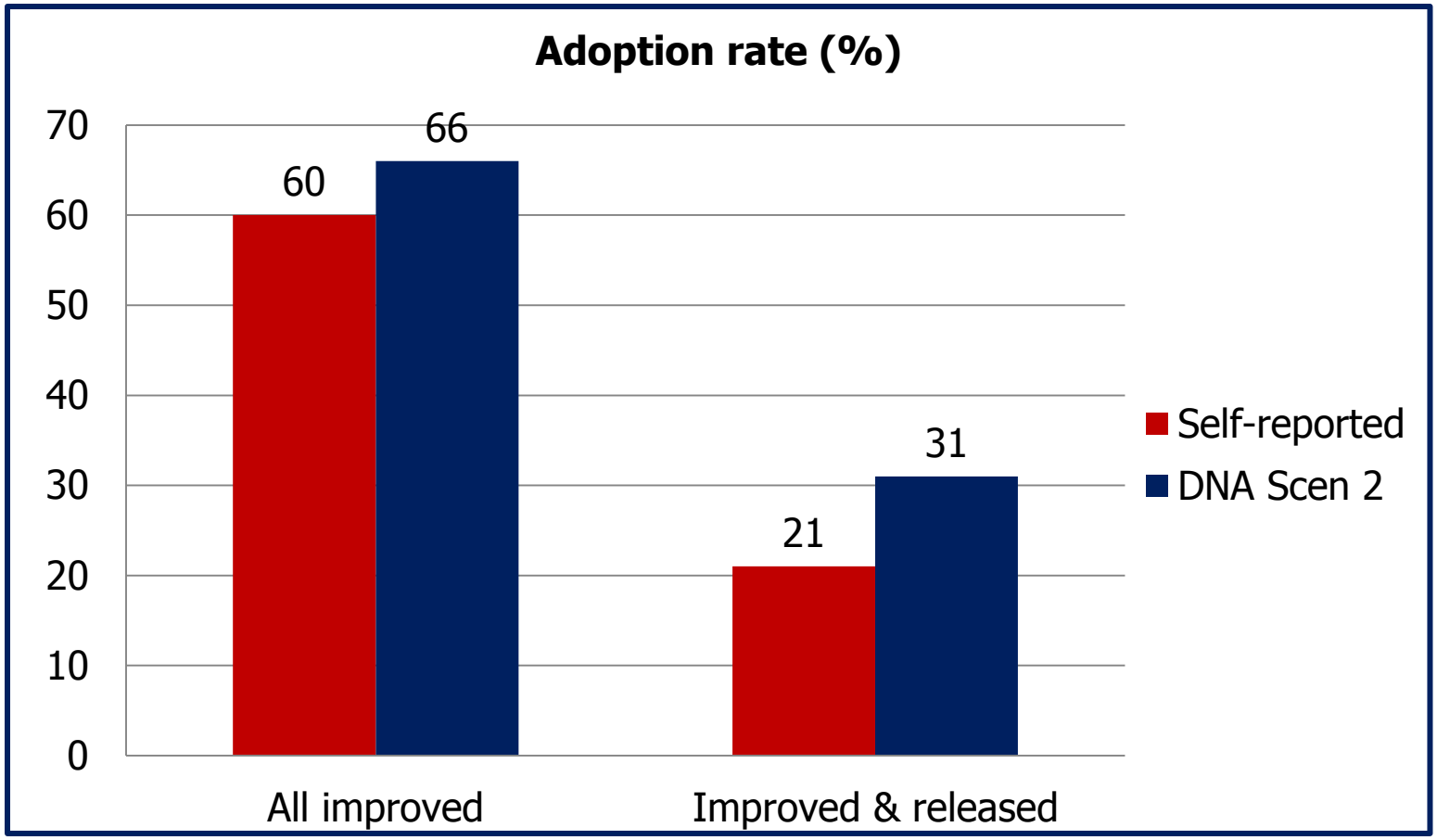
Q1: What is the adoption rate of improved cassava varieties in Nigeria?

What is an improved variety?

Scenario 1 (OR)	Scenario 2	Scenario 3
Only improved and officially released varieties	**All improved varieties**	**Improved varieties + Landrace selections**
✓ Improved and Formally released	✓ **All improved varieties** (formally and informally released	✓ **All improved varieties** (formally and informally released ✓ TME 419 ✓ Land race selections

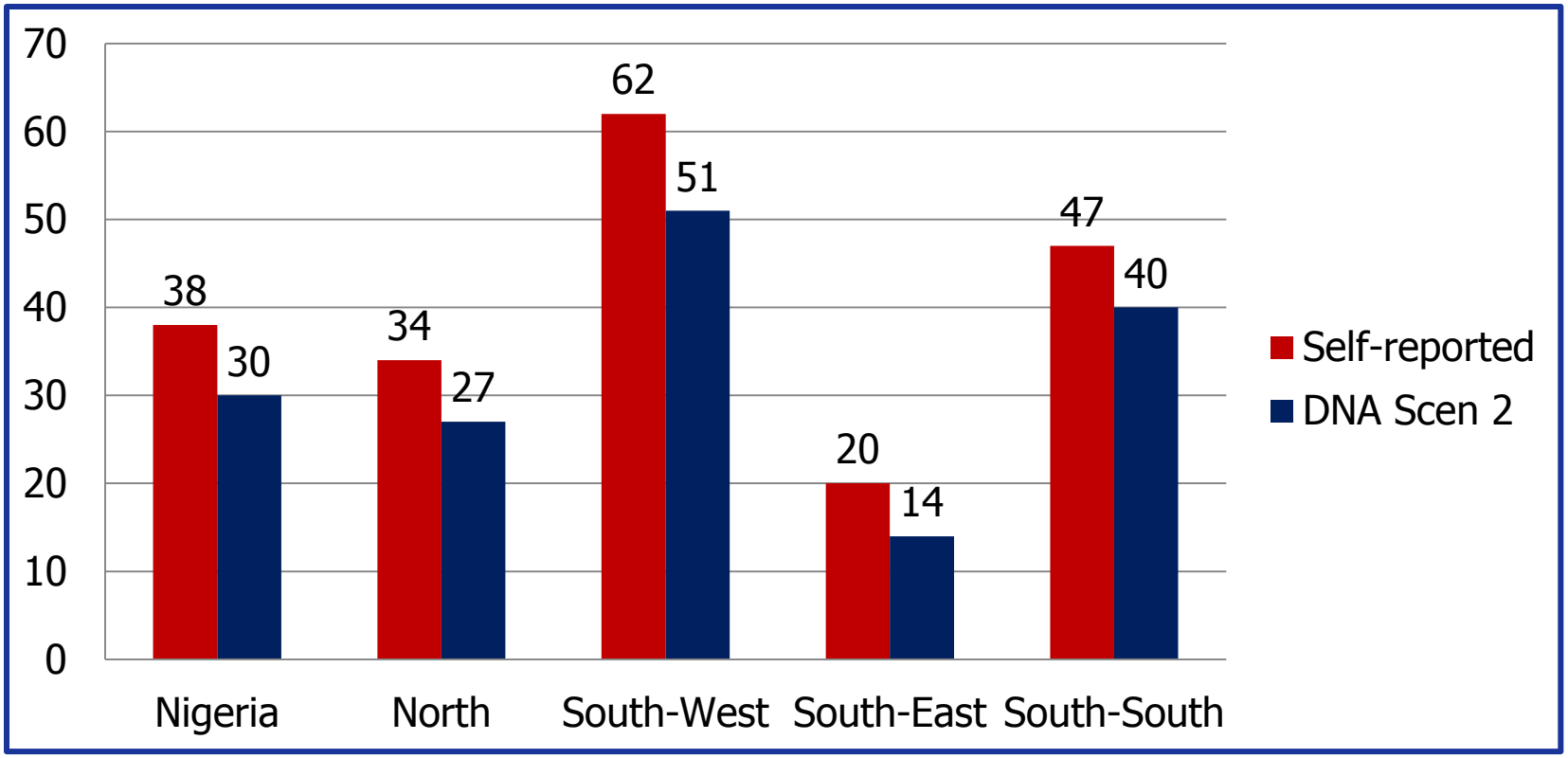
Adoption rate: HH level

Proportion of households who adopted improved varieties



Intensity of adoption

Share of total cassava land under improved varieties



Misclassification: Plot level

		HH surveys	
DNA Scen. 2		Adopter (%)	Non-adopter (%)
	Adopter (%)	34.9	**25.3**
	Non-adopter (%)	**18.4**	21.4

43.7% misclassification rate.

Why do farmers misreport adoption status?

Misreporting adoption status (1)

1. Lack of planting materials

	Full sample	N	SW	SE	SS
Family/Friends/Relatives/Neighbors	**70.4**	**67.8**	**79.8**	**63.1**	**66**
Extension/Government	12.6	13.2	8.1	14.8	16.0
Other sources	17	19	12.1	22.2	18.1

Other sources include: Cassava market, research institutions, Farmer associations, NGOs, Processors

Misreporting adoption status (2)

2. Cultivar turnover

	Full sample	N	SW	SE	SS
Farmers keeping cultivated varieties (%)	94	94.8	94.5	88.4	95.3

Misreporting adoption status (3)

3. Lack of proper identification

- Identifying improved &released varieties by name?

No chance

- Farmers give the same name to different varieties and different names to the same variety.

Release name	Release code	Adoption (%)	Unique names	Most common name
TMS30572	NICASS 1	17.4	237	AGRIC
TMS50395	NICASS 15	4	61	AGRIC

Correct classification

Variables: Dependent variable=1 if correct classification=1	ME
Education	0.016**
	(0.006)
Sex (1=male)	0.172**
	(0.084)
Mobile phone ownership	0.598***
	(0.169)
Access to extension	0.253***
	(0.07)
Access to planting material (official sources)	0.251***
	(0.0725)
Membership in cassava growers association	0.207***
	(0.07)

Other controls included but not reported here. ***, ** & * significant at 1%, 5% and 10%, respectively. **Investment on education, seed market and information market are key**

Q2: What are the main determinants of adoption?

Determinants of adoption

	DNA Scen. 2
Household size	0.018*
Age	-0.020**
Sex (male=1)	-0.004
Education	0.011**
Mobile phone ownership	0.605***
Access to extension	0.178***
Access to credit	0.159***
Membership to cooperatives	0.230***
Availability of planting material	0.101*

Other controls included but not reported here: ***, ** & * significant at 1%, 5% and 10%, respectively.
Some of trait characteristics (Quality of garri, Root yield, Early maturity) were also significant

Determinants of intensification of improved cassava varieties

Determinants of intensity of adoption

	DNA Scen. 2
Age	0.01***
Household size	0.009**
Access to extension	0.032**
Distance from market	-0.003*
Membership to cooperatives	0.035**
Presence of private cassava processor	0.516***
Fertilizer use	0.21***
Availability of planting material	0.053***

Other controls included but not reported here: ***, ** & * significant at 1%, 5% and 10%, respectively. Quality of gari and starch content were significant. **Economic incentives are important**

Why do farmers dis-adopt some improved varieties?

Determinants of dis-adoption

Only 11.6% have dis-adopted

	ME
Distance from market	0.0016**
Lack of planting material	0.343***
Pest and disease problem	0.28***
Availability of better variety	0.268***

Other controls included but not reported here: ***, ** & * significant at 1%, 5% and 10%, respectively.

Conclusions and future extensions

Conclusions

- Cassava producers tend to be small but prone to measurement errors
  - Varietal identification
  - Area under cassava production
- A well-functioning seed system is crucial:
  - About 70% of the farmers rely on social networks for planting material
- For a well-function seed system what are the options?
  - Seed multiplication and distribution efforts (clean and healthy)?
  - Contract farming (Asian experience)?
  - Certification and quality declared planting materials?
  - Public, private or public-private investment in seed system?
  - etc

Possible follow-up?

- We need to better understand:
- Are farmers willing to pay for:
  - Quality declared seed?
  - Certified seed?
- Aspects of returns to farmers & incentives for seed producers
- What other interventions need to be in place for the seed system to flourish? (*Little by little, the egg begins to walk)*
  - Input and output markets
  - Extension
  - Information &policy
  - Regulation etc

Thank you!

CMS: Key Results From Village Level and Gender-Disaggregated Survey

Tahirou Abdoulaye & the CMS team

March, 2017

Research Questions and Scope

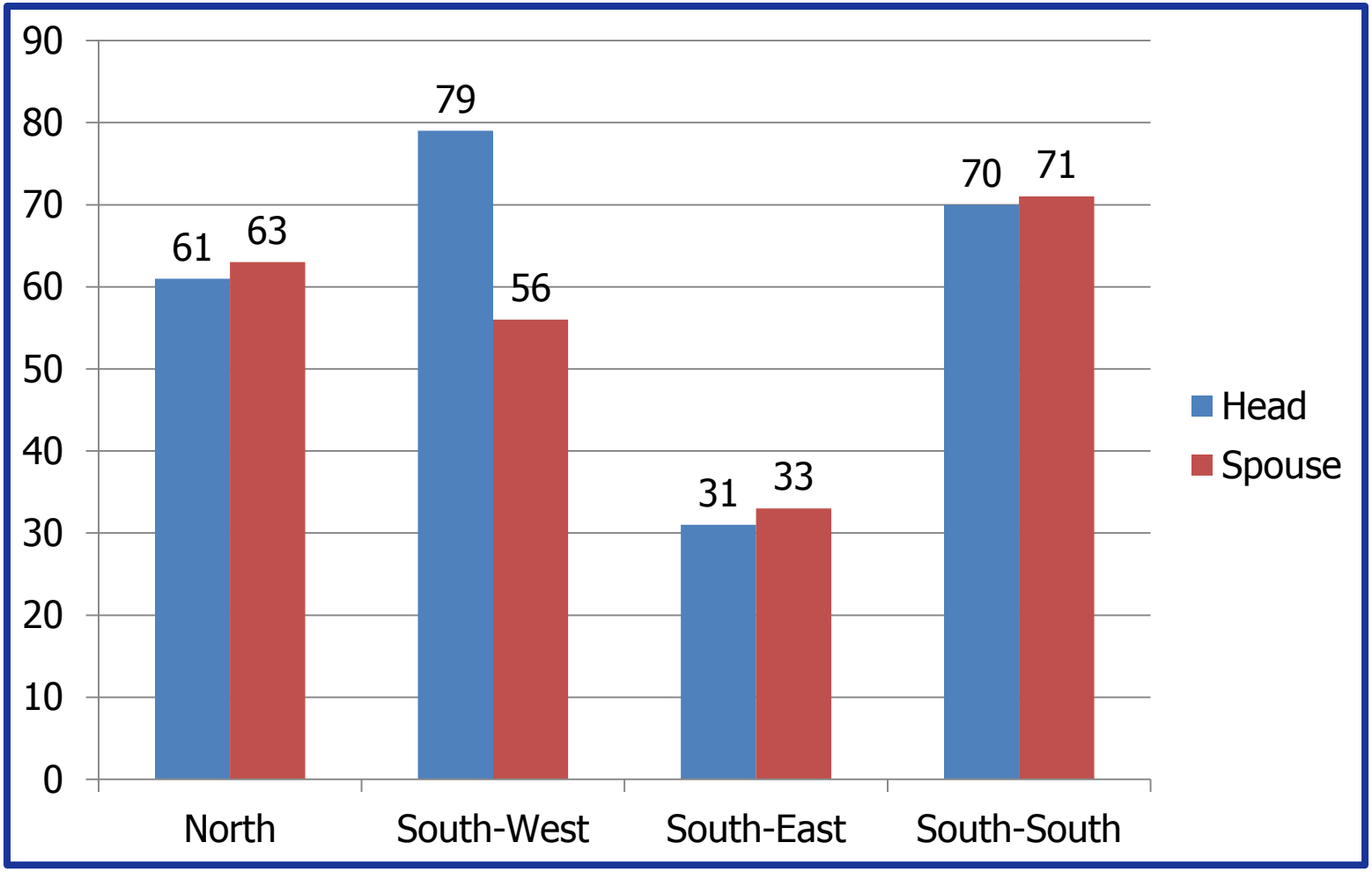
- What were the varietal attribute preferences of different end users in terms of production, processing and consumption traits?
- Were there gender differences associated with varietal adoption, preferences and adoption pathways, and benefits from adoption?
- What are the implications for the seed sector?
- Scope: Survey covered 500 villages in the 4 study regions

Characteristics of villages

	Adopters	Non-adopters	Diff
Distance to the nearest main (district) market in km	10.73	13.5	-2.8***
Distance to the nearest seed dealer in km	10.65	14.3	-3.6***
Distance to the nearest fertilizer dealer in km	11.1	12.94	-2**
Distance to the nearest herbicide/pesticide dealer in km	9.8	13.23	-3.44***
Distance to the nearest farmer cooperative society office in km	10.32	17.8	-7.5***

Results
Gender-disaggregated survey

Adoption rate



Number of improved cassava varieties

- Household heads: 1.8 varieties/household
- Spouses: 1.5 varieties/household

Access to extension services

3) Access to extension

	Head (%)	Spouse (%)
Contact with extension agents	32.5	18.7
Advice on cassava production	18.6	7.4

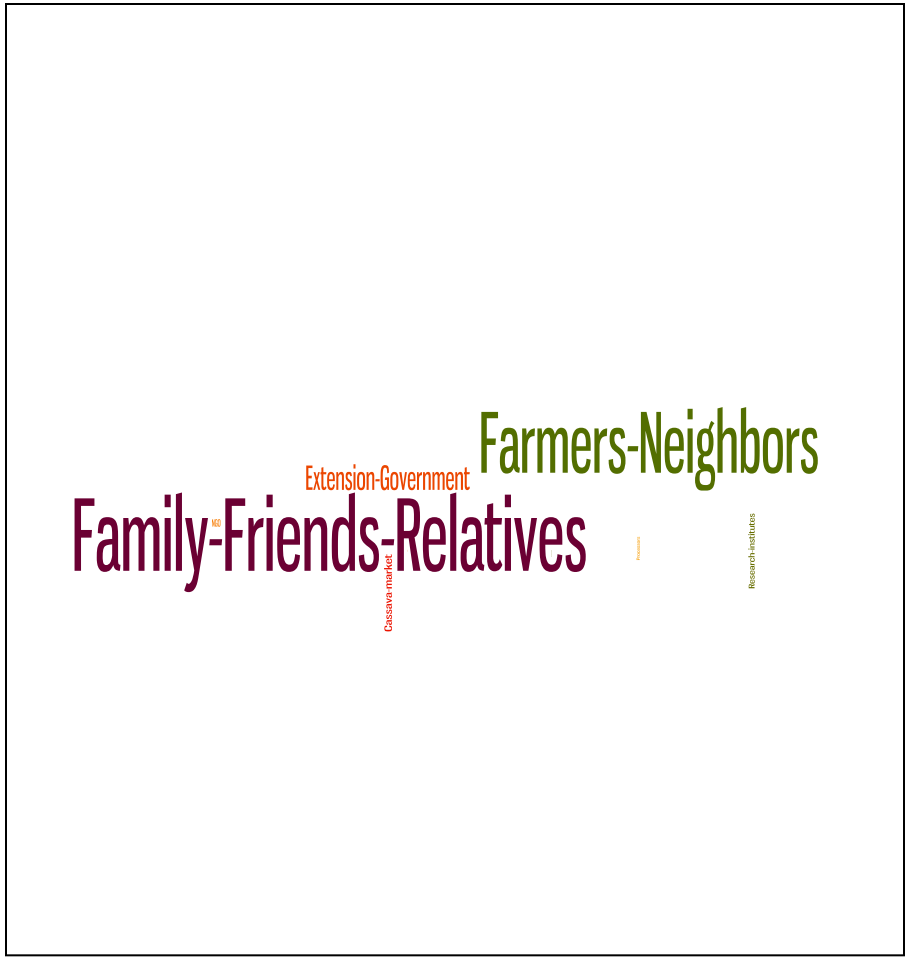
Membership to associations

Associations	Head (%)	Spouse (%)
Religious group	81.8	78.1
Mutual Aid group	31.7	33.2
Credit and savings group	28.6	26.6
Cooperative	17.9	22
Cassava growers association	13.1	17.9

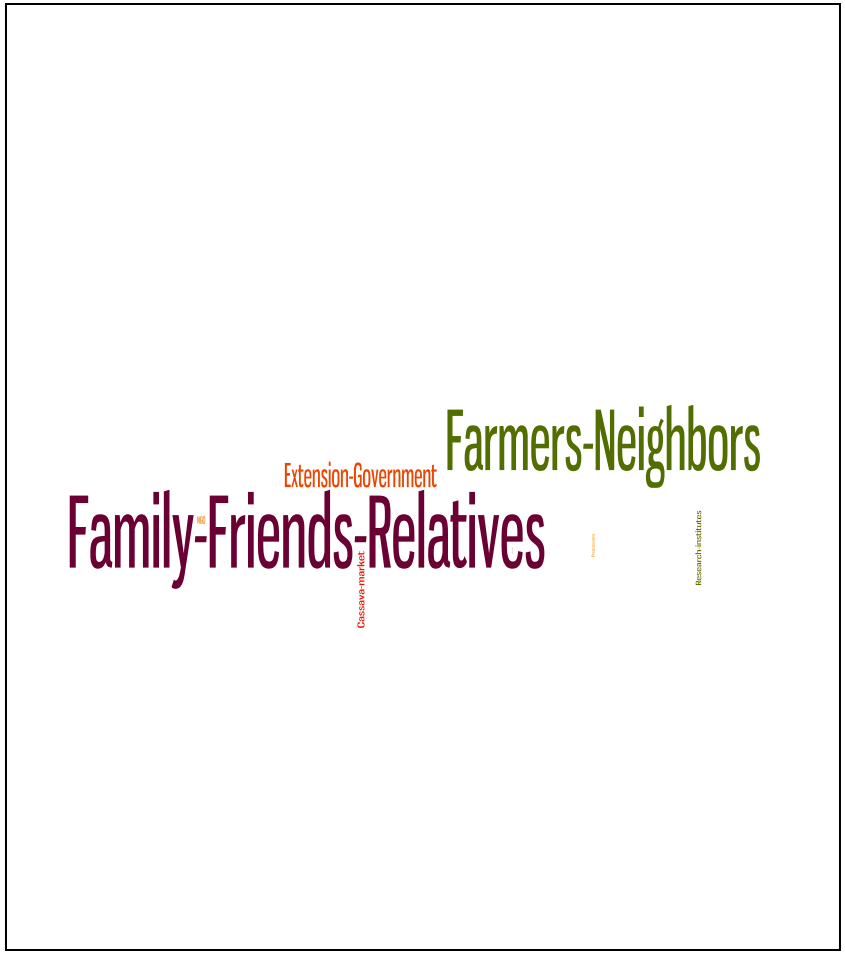
Source of planting material

Access to planting materials

Heads



Spouses



General traits preferences

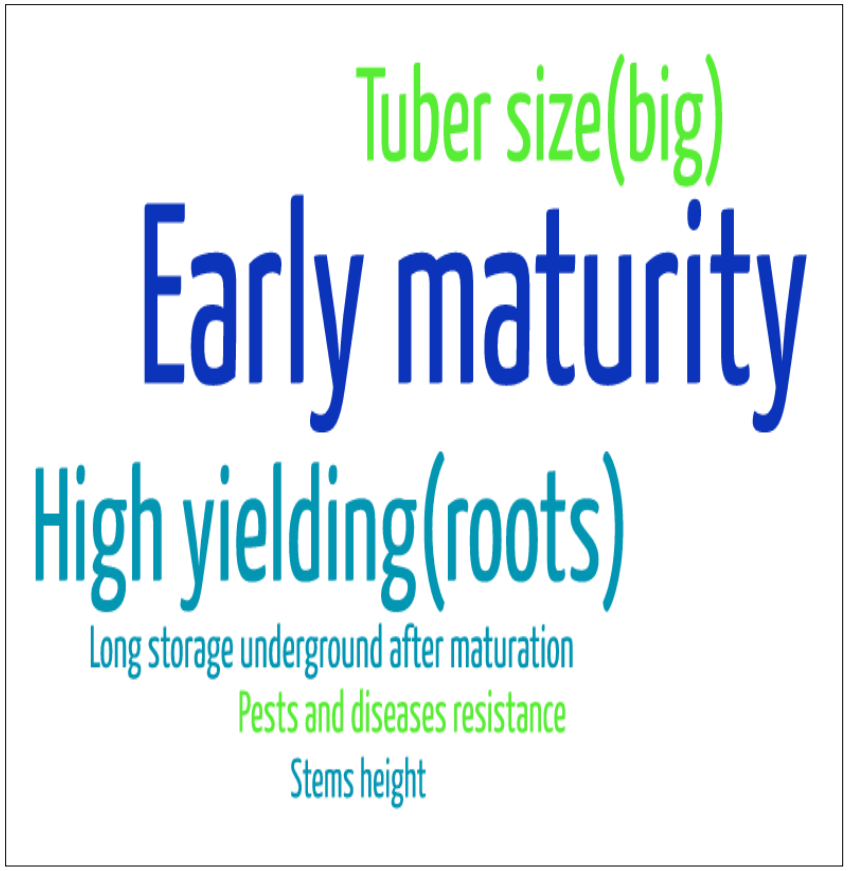
Trait preference

Production	Processing	Consumption
Early maturity	Ability to be processed into gari	Taste for gari
High yielding (roots)	Ease of peeling	Taste for fufu
Big root size	Low water content	Good Poundability

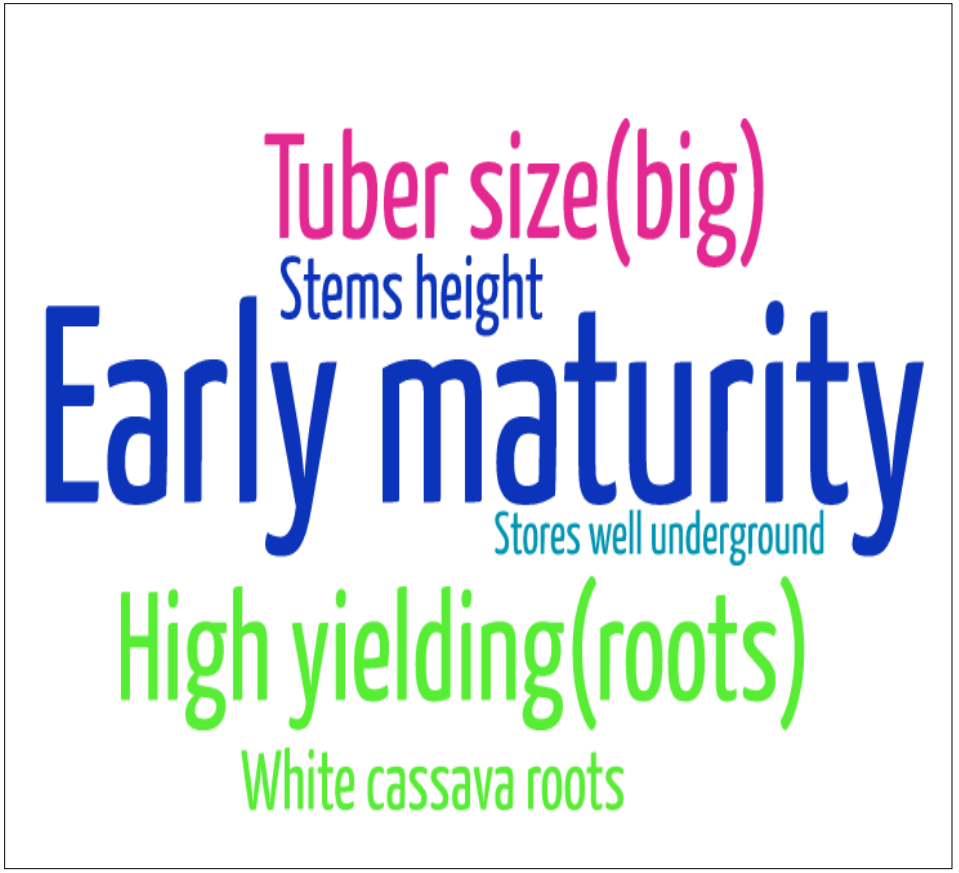
Gender specific trait preference

Production traits preferences

Heads

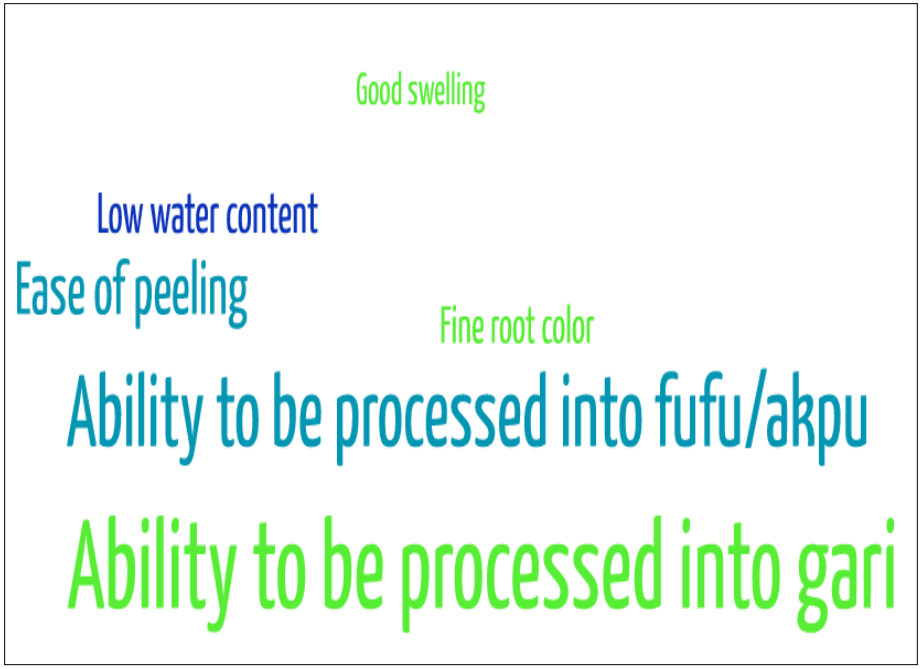


Spouses



Processing traits preferences

Heads

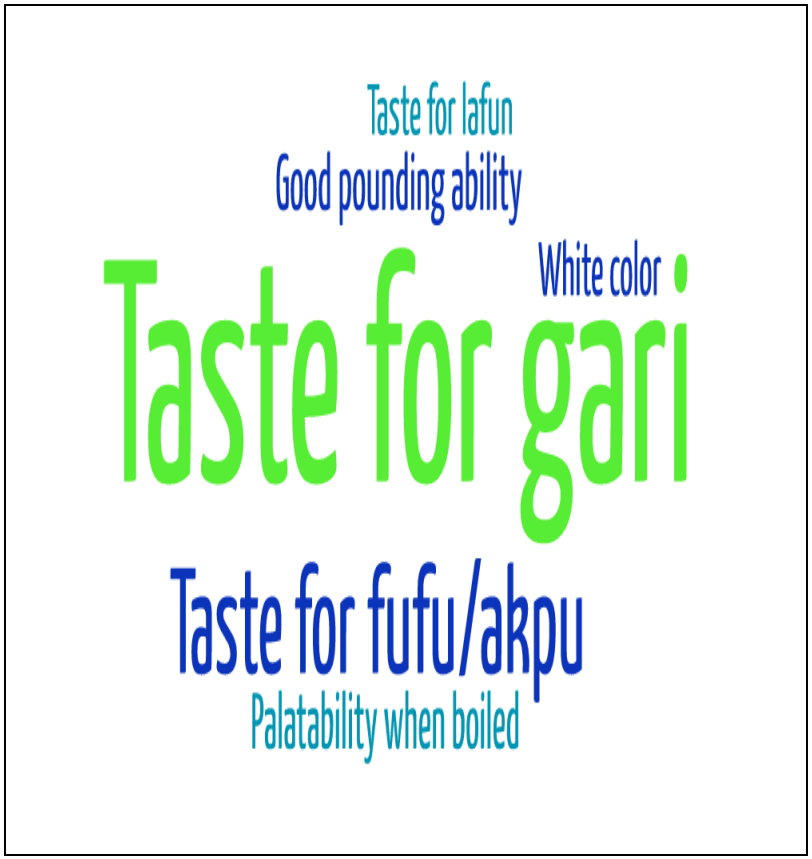


Spouses

Consumption traits preferences

Heads

Spouses



Results
Focus group discussion

Regional heterogeneity

Community	Women	Men
Southwest	Easy to peel, processing, high yielding, early maturing	High yielding, early maturing, stores underground, controls weeds, ready market
North	Easy to peel, high yielding, non-toxic, stores underground, processing	Early maturing, insect resistant high yielding, access to market
South-South	Easy to peel, high yielding, stores underground, processing	High yielding, stores underground tolerates poor soils, early maturing
Southeast	Early maturing, Easy to peel, Stores well underground Big roots (high yielding)	Fast maturing, high yielding Less starch, drought resistant

A blog has been published online on these results:
Results are available on: http://www.rtb.cgiar.org/blog/2016/07/27/listening-women-dont-say/

Cassava seed system

- **Common findings**
- Farmers do not use improved cassava varieties because of a lack of planting materials.
- States-based Agricultural Development Program (ADPs) have assisted in the past to promote farmers access to ICVs. Many are now resource constrained.
- Local seed systems generally move planting material short distances within the village or to neighboring communities.
- **Gender differences**
- Processing and consumption traits are more important for women than for men

Summary

- Availability of Stems continue to be a problem
- Opportunities exist for seed system development (demand side)
  - Most farmers are getting cuttings from FFR: potential market to exploit
  - Some are buying already: So planting materials can be sold
- Challenges
  - Need to understand institutional environment and Economics of cassava seed production (supply side)
  - Marketing and market segmentation need attention


Thank you!