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Characterizing Nigeria's cassava seed system and the use of planting material in three farming communities

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Contents

Abstract

To archive a larger impact of seed interventions, we need to understand root, tuber and banana seed systems better. In the context of the intervention "Building an Economically Sustainable, Integrated Seed System for Cassava in Nigeria" (BASICS), there was a need to better understand the seed-sourcing behavior of cassava farmers and identify entry points for decentralized stem multipliers (DSMs). To this end a multi-stakeholder workshop provided insights into the wider landscape of Nigeria's cassava seed system. In an explorative study we collected qualitative data via focus group discussions and complemented them with quantitative data from a survey of 90 cassava farmers in three study sites with different agro-ecological conditions. Our findings show that the cassava seed system is largely informal with vibrant stem trade within and between communities. Farmers in all study sites maintain a mix of varieties with multiple traits that is adapted to agro-ecological conditions and farmers' preferences for use of roots. They value short maturity for early harvest, long storage of roots in the soil, bitterness as a protection against rodents, and high starch content for preparation of fufu. Although farmers in Nigeria's South South region used only local landraces, farmers in other study sites dynamically combine those with new germplasm from the formal system. Because of a longer dry season, not all farmers are able to cover their need of planting material from their own fields alone. Despite using technologies for storage of cassava stems, there is still a demand for stems from relatives, friends, and neighbors; local traders and seed markets; and agricultural development programs. Differentiation of farmer categories by the size of their cassava fields showed no explainable pattern of different seed-sourcing behavior. Across the study population, the shortage of planting material and farmers' interest in trying out new varieties were identified as entry points for the DSMs of the BASICS project. Further research on seed-sourcing dynamics, however, is needed to create a clear profile of stem buyers. We emphasize the importance of understanding the dynamics and the involvement of various actors in informal seed exchange to harmonize the work of DSMs in a seed system.

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Characterizing Nigeria's cassava seed system and the use of planting material in three farming communities

INTRODUCTION

NEED TO UNDERSTAND RTB CROPS SEED SYSTEMS

Using better varieties and higher quality seed[1] in farmers' fields is one pathway to enhance agricultural productivity and food production. Root, tuber, and banana crops (RTB crops) make a particular case: they play an important role in food security but, because of their vegetative propagation via stems, roots, tubers, or suckers, their seed system is quite different from the seed systems of "true" seed crops. High potential for re-use by farmers, low profitability margins, bulkiness in handling and transport, and quick perishability of the planting material make them unattractive for commercial breeding and private sector seed programs. Despite large investments over several decades (Alene, Abdoulaye, Rusike, Manyong and Walker 2015), the public sector has not been able to meet the expectations in these crops. And although international crop improvement programs have contributed to breeding and release of improved varieties (ibid.), several studies show that farmers are still largely acquiring seed from the informal seed system (McGuire and Sperling 2016; Sperling and McGuire 2010). The complexity of seed systems—including its formal and informal actors and prevailing practices of farmers in multiplying and sourcing seed—needs to be understood in order to archive a larger impact of formal seed interventions (Almekinders et al. 2019). Especially for RTB crops, where the market for planting material is still limited, it is key to understand farmers' demand for clean planting material and more productive, nutrient-rich varieties. In this article we look at the context of a project that aims to build an integrated and economically viable cassava (*Manihot esculenta*) seed system in Nigeria.

THE CASSAVA SECTOR IN NIGERIA

Nigeria is the largest producer of cassava in the world (FAOSTAT 2017). In the western part of the country, the commercial production and processing of the crop into starch, sweeteners, ethanol, high quality cassava flour, and dried chips industries are increasing. Developing industrial products by using a value chain development approach to replace imports of raw materials and to create export commodities are anticipated as major drivers for Nigeria's cassava transformation plan (GoN 2012). Yet the majority of cassava is produced and consumed as a staple crop by smallholder farmers across all agro-ecological zones of the country, in particular

[1] In this article we use the term "seed" not only in its "true" botanical meaning, but also in reference to planting material of vegetatively propagated crops. These include stems, roots, tubers, and suckers.

in the southern and central regions. Harvested cassava roots can be stored for only a few days without spoilage. Therefore, most farmers process the roots quickly after harvest, work that is done mostly by women in the households. In processed form cassava products can be used for household consumption over a few months or sold in the market. The main traditional cassava-based staple foods in Nigeria are gari, fufu/akpu, and lafun. Gari, the most popular product in Nigeria, is a granular flour made by roasting fermented cassava. In some regions the flour is mixed with palm oil to enrich the product's look, consistency, and taste. Fufu/akpu is a fermented wet cassava paste, widely consumed in eastern and southwestern parts of the country. Lafun is a fermented, dried cassava flour commonly used in southwestern Nigeria.

SEED SYSTEM INTERVENTION

Between 1970 and 2010, 65 improved varieties were released in Nigeria (Alene et al. 2015). From the beginning of that period, large-scale interventions, such as the World Bank's support of the Agricultural Development Project and the International Fund for Agricultural Development's (IFAD) grants, supported the distribution of planting material of these improved varieties (Oparinde et al., 2016). Recent studies on the adoption of improved cassava varieties and released landraces in Nigeria identified adoption rates of 46–60% (Alene et al. 2015; Tahirou et al. 2015; Wossen et al. 2017). However, the reported uptake rates vary considerably between studies and different regions in Nigeria. For example, Wossen et al. (2017) identified adoption rates of 79% in the South West region compared with 31% in the South East. Several studies recognize the difficulty in correctly identifying and distinguishing cassava varieties by farmers and formal seed experts, resulting in different estimates of adoption rates (Oparinde et al. 2016; Tahirou et al., 2015; Wossen et al. 2017). Genetic fingerprinting has shown a large rate of misclassification—that is, farmers believe they are cultivating a local landrace although it is an improved variety and vice versa (Wossen et al. 2017). Another issue is that the nature of reporting of adoption rates in these studies reflects neither the intensity of growing improved cassava varieties on farmers' fields nor the dynamics in replacing varieties with newer ones, measured as varietal turnover (Spielman and Smale 2017). From the aspect of implementing public seed delivery programs, a major challenge was long transports of planting material, which resulted in high transaction costs and losses (e.g., damages during loading and off-loading, drying out due to long exposure during transport periods). Therefore, the distribution process was assumed to be often ineffective and below the expectation in reaching out to farmers' fields (Bentley et al. 2017). Across different studies it is recognized that the outreach of improved cassava varieties did not reach its full potential and that initiatives for sustainable seed system development are required.

THE BASICS PROJECT

The project "Building an Economically Sustainable, Integrated Seed System for Cassava in Nigeria" (BASCIS),[2] funded by the Bill and Melinda Gates Foundation, began in 2016. The project aims to build a sustainable seed

[2] http://www.rtb.cgiar.org/basics

system for Nigeria via developing a network of seed entrepreneurs engaged in commercial sale of cassava planting material that is produced with high-quality standards as certified by the National Agricultural Seed Council (NASC). The CGIAR Research Program on Roots, Tubers and Bananas (RTB), led by the International Potato Center (CIP), coordinates the project, which is being implemented in collaboration with the International Institute of Tropical Agriculture (IITA), the National Root Crop Research Institute (NRCRI), and Catholic Relief Service (CRS). The project consortium implements activities that aim to develop a cassava seed value chain from breeder seed to sellers of certified commercial seed. A special focus of the approach is on the integration of the private sector into the cassava seed value chain. BASICS uses a processor-led model (facilitated by Context Global Network of USA) to leverage large-scale industrial producers as conduits for market-led dissemination of improved varieties in a root buy-back arrangement. It also facilitates the establishment of decentralized stem multipliers, called village seed entrepreneurs (VSEs), in Nigeria's South South, South East, and North Central regions. The VSEs have access to early-generation cassava seed from foundation seed producers which they multiply and sell to farmer-clients in the vicinity. In the scope of further shaping the VSE model, there was a concrete need to understand farmers' demand for cassava seed, prevailing seed-sourcing practices, and already established forms of cassava stem trade in the project regions.

KNOWLEDGE GAPS AND OBJECTIVES OF THIS STUDY

There is very little empirical information in the scientific literature on how farmers manage cassava stems, used as seed, on their farms. It is generally assumed that farmers use stems for planting from their own farm because of the ease of propagation, the relative robustness of the crop when it comes to degeneration, and the fact that stems as nonedible parts of the plant have no competing use. Lynam (unpublished manuscript) considered cassava as a crop with the lowest cost of propagation by farmers and where availability of planting material is usually not a constraint. Nevertheless, recent studies indicated substantial off-farm sourcing of seed by smallholder farmers in Africa (Adam et al. 2018; Almekinders et al. 2019; Kansiime and Mastenbroek 2016; McGuire and Sperling 2016). In the context of Nigeria and BASICS, it is not clear how that demand is reflected in potential seed markets and what the client profile in the project region would look like. Therefore, the objectives of this study were to understand better the local cassava seed system, including farmers' practices of using cassava seed, their sources, and actors involved. In addition, the study aimed to identify potential entry points for VSEs in the BASICS project to strengthen the seed system. Our objective was not to present a picture of practices that is representative for Nigeria as a whole, but to present some cases that show a variation of situations that exist and how this links up with the wider functioning of the cassava seed system in Nigeria.

METHODS

APPROACH

Studies on the adoption of improved cassava varieties are mostly based on a larger sample of respondents and aggregated data across different cultural and agro-ecological zones (e.g., Wossen et al. 2017). Those studies

often do not show the variations in outcomes between different regions, social groups, and gender (e.g., Oparinde et al. 2016). In contrast, our study focused on variations in context and social differentiation of farmers through the use of an explorative research design, combining qualitative data from rapid rural appraisals via focus group discussions (FGDs) and a relatively small sample size of quantitative data in three farming communities in Nigeria. Expert interviews from workshops and meetings provided insights into the wider landscape of the Nigerian cassava seed system. All data were collected within the scope of monitoring activities of the BASICS project. The primary focus of this exercise therefore was an understanding of the context of farmers' cassava seed use and stimulating a joint discussion of findings with the study team.

DATA COLLECTION

A study team consisting of the authors of this article carried out fieldwork and expert workshops from August to December 2017. During a scoping visit we identified study collaborators, defined research objectives, and jointly developed a study design to address the initial research questions. After a preliminary data collection phase in October 2017, we met to (1) discuss the first findings with a larger group of experts from NRCRI and BASICS partner organizations and (2) develop questionnaires for a survey in a second study phase in November/December 2017.

For the collection of field data in two phases, we selected three study sites in the BASICS project area. These sites represent the major different cultural and agro-ecological zones: *Umuohuodi* (Umuapu Ohaji/Egbema local government area [LGA], Imo State, South East Zone); *Ibiaku Ntok Okpo*[3] (Ikono LGA, Akwa Ibom State, South South Zone); and *Ashina* (Gwer East LGA, Benue State, North Central Zone). Contact persons from the national Agriculture Development Program (ADP) facilitated the selection and established contact with the three communities. The criteria for site selection were threefold: presence of small to large-size farms; not strongly influenced by but in the catchment areas of BASICS project activities; and areas where cassava is a major crop in farming systems.

In the study preparation phase, we held two FGDs with farmers from Imo State and Benue State who were associated with the BASICS project on how they would differentiate cassava farmers in their communities. On the basis of these discussions, we defined three categories of cassava farmers: *small* (size of cassava fields < 0.5 ha), *medium* (size of cassava fields 0.5–2 ha), and *large* (size of cassava fields > 2 ha). In each study site gender-balanced FGDs served as an entry point to the community and helped to explore the local context of farming and growing cassava. As part of this effort we carried out a survey based on farming households that reflected all defined farmer categories via purposeful sampling. The survey contained questions on household level and were administered to both women and men (40% and 60%, respectively). In addition to collecting data from farmers in the communities, the study team carried out semi-structured interviews with cassava stem traders in the vicinity of the study sites (Table 1).

[3] The sample included farmers from different villages in the community Ibiaku Ntok Okpo, namely Ikot Akpan Udo, Ibiaku Ata, Itak Ikotakpandem, Ikot Ofiong, Ibiaku Ikot Edet, Ikot Ukana, Nkara Obio and Nung Ukim.

Between the two study phases, the study team held an expert elicitation, which was guided by the RTB Multi-stakeholder Framework (RTB 2016). A group of 16 participants—8 from NRCRI, 2 from CRS, 2 from CIP, 2 from Wageningen University & Research (WUR), 1 private seed entrepreneur, and 1 CRS consultant—jointly analyzed the cassava seed system. The analysis was based on empirical data from the preliminary study and a matrix for seed system diagnosis from the RTB Multi-stakeholder Framework.

Table 1. Number of interviewed farmers in individual interviews and number of FGDs in the three study sites

	Respondents of individual interviews			
Study site	***Small farmers***	***Medium farmers***	***Large farmers***	**FGD participants**
Ibiaku Ntok Okpo (South South Zone); first study phase	5 (1 male/4 females)	5 (3 males/2 females)	5 (5 males/0 female)	23 (10 males/13 females), 12 (7 males/5 females)
Ibiaku Ntok Okpo (South South Zone); second study phase	5 (1 male/4 females)	6 (5 males/1 female)	4 (3 males/ 1 female)	10 (9 males/1 female)
Umuohuodi (South East Zone); first study phase	5 (2 males/3 females)	8 (5 males/3 females)	3 (1 male/2 females)	28 (10 males/18 females), 13 (5 males/8 females)
Umuohuodi (South East Zone); second study phase	4 (2 males/2 females)	6 (2 males/4 females)	4 (2 males/2 females)	11 (5 males/6 females)
Ashina (North Central Zone)	9 (7 males/2 females)	26 (20 males/6 females)	12 (6 males/6 females)	10 (5 males/5 females), 16 (12 males/4 females)

We analyzed recorded data from FGDs and expert meetings with qualitative content analysis, grouping most-discussed topics and most-prominent issues that were mentioned. The structured data from surveys in the three farming communities were collated into a spreadsheet and analyzed with descriptive statistics, using Microsoft Excel®. We did not apply statistical analysis on the survey data, as our objective was not representativeness but a comparison of different study sites and categories of farmers within the sites. Resource persons from IITA headquarters in Ibadan, ADP agents in the study regions, and knowledgeable farmers in the study sites supported the identification of cassava varieties via their local names and characteristics.

FINDINGS FROM THE EXPERT ELICITATION AND THE STUDY SITES

THE CASSAVA SEED SYSTEM IN NIGERIA

Currently, the cassava seed system in Nigeria is largely an informal one that, according to the key experts, shows a vibrant stem trade involving multiple actors of both the formal and informal seed systems (Almekinders, Pircher, and Obiesan 2017). Farmers make up the largest and most diverse group in this system, and continuously source and share cassava stems among each other and with a wider group of actors in the seed system. NRCRI and IITA, formal actors in the system, are considered as the key institutions for the introduction of improved varieties and early-generation planting material into the seed system. Both institutions have adopted a commercially driven approach, in which they engage private sector seed entrepreneurs for multiplication and sale of foundation seed and certified seed. NASC holds the mandate to certify breeder seed, foundation seed, and commercial seed. Another formal sector player is ADP. Despite being constrained by funds for purchasing and distributing cassava seed, the network of ADP extension agents has an active role in stem trade. The agents currently act as brokers in the system by facilitating stem sales among farmers and between farmers and stem sellers. NGOs, churches, and local governments are hubs, in which cassava seed is purchased and distributed for free to farming communities. Interviews with VSEs in the study preparation phase showed that a large part of their seed turnover is based on institutional sales, which offer attractive payment modalities, large transaction volumes, and reliable sales for the entrepreneurs (Walsh, unpublished workshop report 2017).

The link to and between farmers is built by informal seed traders. These range from small farmer traders, who sell 50–100 bundles (a unit for 50 cassava stems 1 m long) a year to large commercial traders, who sell 2,000 bundles or more a year. Interviews with 17 stem traders across Imo, Akwa Ibom, and Benue states indicated that 82% of the traders sell improved varieties and 52% sell local varieties. The traders disclosed that the majority of their customers buy planting material from them either because of the good quality of stems or because they are looking for new varieties. Some 76% of the traders indicated that their clients ask for specific varieties, which included local (e.g., '6-Months') and improved ones (e.g., the recently released variety 'TME 419' and biofortified vitamin A varieties). In FGDs clients of BASICS VSEs reported cases in which larger farmers act as traders in the system. For example, one large cassava grower in the region irrigates his farm and thus is able to sell cassava stems to farmers in the vicinity during the dry season when many farmers are short of seed.

Drawing a seed-flow map with participants of the workshop illustrated that a communication network (largely facilitated by using mobile phones) is the backbone of cassava stems brokerage. After identifying potential suppliers, farmers (stem buyers) and traders organize transport to farmer fields via trucks, pick-ups, or motorcycles. Workshop participants also reported large-scale transactions between traders across longer distances (e.g., between different states). Sellers, who are situated along frequented roads, commonly flag the availability of stems on their farms by putting a pile of stems next to the road. In most cases, buyers organize transport and harvest the stems from the sellers' farms themselves. In some areas in Nigeria (e.g., across

Benue State and some sites in Imo State), specialized cassava stem markets exist where traders and seed producers offer planting material for sale.

CHARACTERIZATION OF THE THREE STUDY SITES

Across all study sites (Figure 1), individual interviews with farmers indicated that all households in the communities are headed by a male, except those that are widowed. The role of men and women in decision-making for varietal choices, identifying sources for planting material, and marketing of produce varies between the study sites. In Umuohuodi and Ibiaku Ntok Okpo, these decisions are mostly taken together by men and women, whereas in Ashina they are taken mostly by men. The three study sites also show considerable differences in cassava-farming practices, marketing, and use of stems. The reasons behind the differences were explored in FGDs in the communities and further discussed with key informants. Most important aspects are different agro-ecological zones (e.g., longer dry season in Benue State), size of landholdings, connection to markets/traders for cassava products, and cultural food preferences.

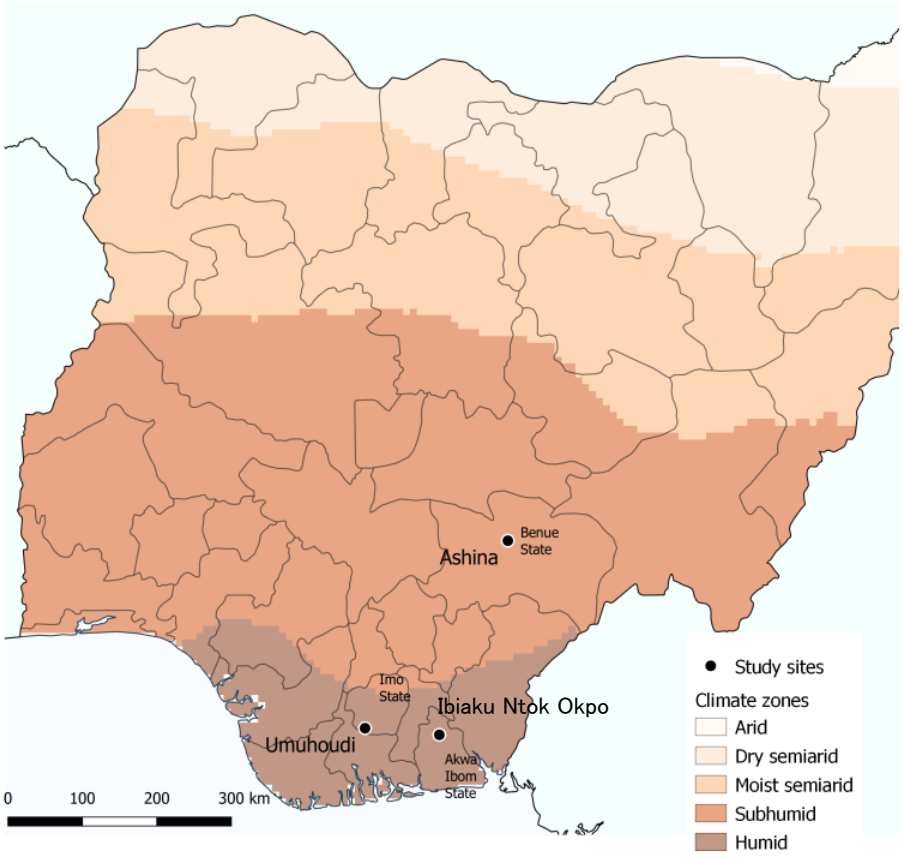

Figure 1: Map of Nigeria's agro-ecological zones with three study sites. (Produced with QGIS 3.4 using GIS data from HarvestChoice, 2015.)

In **Ibiaku Ntok Okpo** (located in Akwa Ibom State), the vegetation is predominantly lowland rain forest. The most important food crops are cassava, yam, maize, rice, and cocoyam. Other crops include okra, melon, pepper, sweetpotato, eggplant, pineapple, oil palm, bread fruit, plantain/banana, orange, local cowpea, local pear (*ube*), and coconut. Most farmers in the community keep livestock such as goats, sheep, and local chickens. Cassava as the major food crop is usually intercropped with maize and melon. The growing season for cassava is during the rainy season (March–October), which is usually planted at the onset of the rains in March/April. Fertilizer is used only to a limited extent. The cassava roots are processed into gari and fufu for home consumption; local markets exist for gari and raw cassava roots. Land fragmentation results in relatively small farm sizes compared with the other study sites and is seen as a challenge to cassava farming. The community is well connected to the Akwa Ibom ADP, which provides improved cassava planting material to farmers. The ADP has also created awareness through on-farm adaptive research with rural households and formed a cassava growers association. Cassava stems are exchanged only between farmers in the community; no stem traders are active in the community.

In **Umuohuodi** (located in Imo State), the vegetation is humid tropical rainforest. Cassava is the most important staple crop and is typically intercropped with telferia, maize, and okra. Plantain, banana, and pineapple are also grown in the community. Most farmers keep livestock such as goats, sheep, and poultry. Cassava is typically grown in the rainy season (March/April–October) and processed into gari, fufu, and tapioca (a form of processed root for starch production) for home consumption and sale to traders on the nearby market. Farmers usually do not apply fertilizer and grow cassava as mixed cropping together with vegetables, plantains, and sometimes yam. Large areas of land are available and mostly communally owned. Personally owned lands exist and are used for cassava cultivation, too. The community is not well connected to the ADP office; cassava stems are commonly sourced from small traders and on the local market on the day of *Eke* (every four days).

Ashina (located in Benue State) is situated in the savanna zone with a considerably shorter growing season (May–October), followed by 6 months of dry season. The interviewed cassava farmers own large areas of land (up to 15 ha), which they cultivate with cassava, soy, sorghum, rice, yam, groundnut, and vegetables like pepper and okra, and fruit trees (e.g., citrus). Cassava and soy are considered to be main crops. Roots are predominantly processed into akpu and gari for home consumption and sale on the market. Markets for seed and produce of cassava and other crops are more developed than in the other two study sites. For example, starch as a by-product from processing and cassava chips are sold to traders in the outreach of the farming community. An ADP agent actively involves farmers in the community in extension activities and provides them new, improved cassava seed. Through a seed exchange scheme, the farmers have to share the same number of cuttings they receive from ADP with other community members after their first harvest. In addition, commercial traders sell cassava stems in large quantities, and farmer-traders in the vicinity sell small amounts of stems next to the roadside.

FARMING PRACTICES AND STORAGE OF PLANTING MATERIAL

Farmers at all study sites typically plant cassava on mounds or ridges or directly in the soil and mix it with other crops (e.g., maize, sorghum, soy, beans, yam). They use cuttings 20–30 cm long as planting material. Depending on the variety and prevailing climate, the roots are harvested after 6–12 months. It is common to harvest *piecemeal*, gradually harvesting smaller portions of the fields, and/or *in bulk*, harvesting larger portions of the field at once. Almost all farmers across all study sites indicated that in the last 12 months they harvested piecemeal. For example, farmers harvest one or two rows of their cassava field every week. Across all study sites, only a few (6%) farmers harvested in bulk, citing as reasons the need for cash to solve domestic challenges or to make larger investments like building houses, or to prevent cassava roots from decaying after heavy rainfall. Some farmers leave roots longer (up to 2 years) in the soil as a strategy to extend the availability period, labor constraints for harvesting, or to wait for the rainy season when they can plant the stems.

The harvest regime also affects the availability of stems for planting. Piecemeal harvesting allows farmers to continuously use stems for planting after harvesting their cassava fields gradually. Particularly the large and medium farmers across study sites stated that they have another strategy: they reserve a portion of their cassava fields for harvesting stems for planting the remaining area. Other widespread strategies for using own-planting material are *ratooning*, which refers to cutting one or more stems while leaving the cassava root in the soil, and *milking,* which refers to harvesting the root only partially to allow the stem to re-grow. To conserve seed during the period between harvesting and replanting stems, farmers apply practices like digging a hole and covering stems with soil or with palm fronds to provide shade. In Ibiaku Ntok Okpo, some farmers reported planting stem cuttings in nursery beds during the dry season before replanting them on their fields. In Ashina, which has a longer dry season than the other study sites, some farmers plant the cassava stems in swampy areas to conserve them until the planting season starts.

CASSAVA VARIETIES IN USE AND ACCESS TO NEW GERMPLASM

Farmers at the three study sites grow a portfolio of one to six different cassava varieties per farming household, which they distinguished as *local* or *improved* varieties. When scrutinizing how *local* varieties initially reached the community, it was shown that many of those varieties were formally released a long time ago and considered “local” by farmers. We therefore do not apply the terms *local/improved* to varieties in the following sections of this article. The interviewed farmers used local names for most of the varieties planted. For some varieties farmers used different names (e.g., they use the names ‘6-Months’ and ‘Give Me Chance’ for the same variety). In Ibiaku Ntok Okpo, farmers used the local name ‘Long John’ for a variety because of its distinctive stem architecture with a non-branching and very straight stem. A follow-up revealed that the variety is formally known as ‘TME-419’. The local ADP agent explained that some farmers are not aware that both names refer to the same variety because they have received the variety from different sources.

In FGDs farmers described the characteristics of their most popular varieties in the studied communities (Table 2). All varieties in use have traits that farmers like and traits they dislike. For example, farmers in Umuohuodi explained:

> Nwaocha is very good for fufu as the color is usually brighter than other varieties. It is the preferred variety for fufu and gari [indicating high starch content. However,] … it is often eaten by rodents because it is sweet unlike other varieties.
>
> 'Abeokuta' matures earlier than other varieties. [However,] … it absorbs plenty of water in the rainy season and retains small water during the dry season.
>
> 'Ahunna', when matured, the stem usually starts drying from the top; it dries quickly and breeze easily affects it.

In Ibiaku Ntok Okpo, farmers explained that the variety 6-Months / Give Me Chance is grown in almost every household because it matures within 6 months and yields are reasonably high. However, the variety does not store well underground as it decays relatively early. A follow-up on the variety revealed that the variety was never formally released in Nigeria. Farmers acquired it from on-site field trials that IITA conducted in 1976, and it spread in the region as discovered by a survey IITA conducted in 2009 (Peter Iluebbey, *pers. comm.*, IITA). Farmers described the variety 'Long John' ('TME-419') as "sweet," referring to a non-bitter type and therefore often eaten by rodents. To protect cassava roots from rodents, farmers also valued bitter-type cassava varieties. The farmers did not appreciate the earlier established varieties 'Ekauya', 'Paya', and 'Afiokpo' and gradually quit planting them.

FGDs across all study sites indicated that farmers are interested in trying out new cassava varieties (Table 2). This was confirmed in the survey, where farmers at all study sites and in all farmer categories stated that their main motivation for sourcing seed off-farm was to "try new varieties". For example, four out of five farmers in Ashina who obtained seed from other sources than their own fields in the last 12 months did so because they wanted to try new varieties. Not all responses of farmers at the other two study sites could be attributed either to variety or to quality of seed (e.g., indicating "my own stems are not yielding well anymore"). However, "new variety" was explicitly mentioned by farmers from all study sites and categories. Study participants in Ibiaku Ntok Okpo reported a new variety, called 'Stainless', for which we were unable to identify its formal name. The Akwa Ibom ADP recently introduced the variety, which is mostly in the hands of medium and large farmers. In FGDs participants explained that those farmers share seed of the variety with other farmers in the community and, on some occasions, ask for money for the stems. Similar patterns of variety diffusion in communities were reported in FGDs in Ashina. In Umuohuodi, however, the varieties in use seem more static: Farmers recalled the varieties 'Nwaocha' and 'Agric' to be in the community for about 10 years. The other varieties have been there for much longer, which farmers were unable to trace back.

Table 2. Most popular cassava varieties (grown by more than 10% of farmers) in the three study communities and distribution among farmers

Study site	Name used by farmers	Formal name	Release date	Farmers who grow variety
Ibiaku Ntok Okpo, Akwa Ibom State (N=30)	6-Months/Give Me Chance	K195 / K29	Not released, IITA field trials in 1976	100%
	Long John/TME 419	TME-419	2005	70%
	Vitamin A/vitamin C/ vitamin E	TMS 011368	2011	43%
	Stainless	*unknown*	Unknown, recently	17%
	Five-Five	TMS 30572	1984	13%
Umuohuodi, Imo State (N=30)	Abeokuta	*Landrace,* also known as Imo Best/Dabere	*not released*	100%
	Nwaocha	*Landrace*	*not released*	90%
	Ahunna/Vuo Lee	*Landrace*	*not released*	80%
	Akpu Red	*Landrace,* also known as Nwaibibi	*not released*	60%
	Agric	*Landrace*	*not released*	20%
	Egbe nwuri	*Landrace*	*not released*	17%
	Agu Egbu	*Landrace*	*not released*	17%
Ashina, Benue State (N=47)	TMS 1368	TMS 011368	2011	62%
	Akpu Fefa	*unknown*	Unknown, long time	60%
	TMS 30572	TMS 30572	1984	45%
	TMS 0505	TMS 980505	2005	40%
	Akoyawo	TME 7 (Oko-Iyawo)	*Landrace*, identified in 1971	30%
	Dangbo	TME 2 (Odongbo)	*Landrace* and released as variety in 1986	15%
	TME 419	TME-419	2005	9%

Release dates/date of identification were identified from http://my.iita.org/accession2/accession/TMe-7 and http://seedtracker.org/cassava/index.php/released-cassava-varieties-in-nigeria/

The most common pattern of variety diffusion within—and to a smaller extent also between—communities is based on informal seed-sharing among relatives, friends, and neighbors (RFN) (Table 3). Data from questionnaires and FGDs identified ADP and traders as entry points to the communities. Ashina is well connected to ADP, and some farmers received new varieties directly from the local agents. For example, a farmer said she was referred by the local APD agent to an IFAD-funded program from where she received 500

bundles of stems of a new variety ('TME 419'). In Ibiaku Ntok Okpo, the ADP agent provided farmers with new varieties and entered into an agreement to supply a part of the yield back to ADP or to appointed farmers in the next seasons for further dissemination. In Umuohuodi, which is poorly connected to ADP services, more farmers reported that they received new varieties for the first time from traders and local markets.

Table 3. Mean numbers of different cassava varieties per farmer category in the three study sites and initial sources of varieties based on data from second study phase only

Study site	Farmer category	Mean no. of varieties/farmer standard deviation (SD)	Initial source of the varieties		
			RFN	ADP	Traders
Ibiaku Ntok Okpo	Small (n=5)	3.8 (0.8)	3.6	0	**0.2**
	Medium (n=6)	3.3 (0.8)	2.8	**0.3**	**0.2**
	Large (n=4)	2.3 (1.3)	2.3	0	0
Umuohuodi	Small (n=5)	3.4 (1.1)	2.8	**0.2**	**0.4**
	Medium (n=6)	3.8 (1.6)	3.8	0	**0.3**
	Large (n=4)	3.8 (0.5)	3.3	0	**0.5**
Ashina	Small (n=9)	2.0 (1.1)	1.7	**0.3**	0
	Medium (n=26)	2.6 (1.0)	2.0	**0.5**	0.1
	Large (n=12)	3.3 (1.3)	2.4	**0.9**	0

SOURCING AND SHARING OF CASSAVA PLANTING MATERIAL

Farmers across all study sites use cassava seed from multiple sources in a single season: their own fields, RFN, the ADP, and traders. The dominant source of stems was farmers' own fields. Off-farm seed sourcing varied considerably between study sites and farmer categories (Table 4). In Ibiaku Ntok Okpo, most small and medium farmers sourced stems from their own farms or in a combination of own- and off-farm, whereas the majority of large farmers sourced exclusively from their own farms. In Umuohuodi and Ashina, most farmers sourced planting material exclusively from their own farms. The group of large farmers in Umuohuodi was the exception: a larger percentage sourced their planting material in a combination of own- and off-farm.

Table 4. Mean size of areas planted with cassava per farmer and sources of cassava stems used by the farmers from different categories in three study sites in the last 12 months

Study site	Farmer category	Mean size cassava areas (ha) (SD)	Own-farm only (%)	Off-farm only (%)	Combination (%)
Ibiaku Ntok Okpo	Small (n=10)	0.4 (0.1)	10	30	60
	Medium (n=11)	1.5 (0.4)	18	27	55
	Large (n=9)	3.4 (1.1)	78	0	22
Umuohuodi	Small (n=9)	0.3 (0.1)	67	0	33
	Medium (n=14)	1.4 (0.5)	71	0	29
	Large (n=7)	3.4 (1.2)	43	14	43
Ashina	Small (n=9)	3.7 (0.1)	89	0	11
	Medium (n=26)	1.2 (0.4)	81	4	15
	Large (n=12)	4.1 (2.7)	92	0	8

In the second study phase, data on the volumes of cassava stems from all seed sources were collected from farmers. The analysis shows that the majority of stems were sourced from their own fields (Table 5), reflecting a lower intensity of use for seed that is sourced off-farm. Only the group of small and medium farmers in Ibiaku Ntok Okpo received a considerable amount of stems off-farm, in particular from RFN, with 32% and 18%, respectively. In Ashina and Umuohuodi, smaller amounts of stems were sourced from RFN, ADP, and traders/local market. Across the different study sites and farmer categories, no clear pattern of the amounts and sources of seed appeared in the sample nor in FGDs with the communities.

Table 5. Volumes of cassava planting material that farmers used from own field and sourced off-farm in the last 12 months

Study site	Farmer category	Mean volumes in bundles (SD)	Own-field (%)	RFN (%)	ADP (%)	Traders/local market (%)
Ibiaku Ntok Okpo	Small (n=5)	23.5 (20.0)	62	32	0	6
	Medium (n=6)	32.9 (39.0)	82	18	0	0
	Large (n=4)	85.8 (22.0)	100	0	0	0
Umuohuodi	Small (n=5)	49.4 (21.3)	96	2	0	2
	Medium (n=6)	175.6 (63.4)	97	0	0	3
	Large (n=4)	220.4 (168.5)	95	3	0	2
Ashina	Small (n=9)	27.2 (14.4)	92	0	8	0
	Medium (n=26)	65.1 (18.4)	91	4	2	3
	Large (n=12)	170.7 (66.7)	89			0

Note: Figures are based on data from second study phase only.

The most frequently reported reason for off-farm seed sourcing in Ibiaku Ntok Okpo and Umuohuodi was the shortage of planting material from their own fields (reported by 10 of 20 farmers in Ibiaku Ntok Okpo and 9 of 15 farmers in Umuohuodi). Farmers explained that they were short of planting material due to theft, infestation by termites, inadequate availability of own stems, and the need for more stems to expand farms. This was followed by the interest of trying a new cassava variety (reported by 7 of 20 farmers in Ibiaku Ntok Okpo and 4 of 15 farmers in Umuohuodi). In Ashina most farmers stated that they source seed off-farm because of their interest in trying a new cassava variety (reported by 7 of 11 farmers), followed by the shortage of planting material from their own fields (reported by 3 of 11 farmers). The latter was due to plans by all three farmers to expand their farms. Few farmers (1 of 11 in Ashina, 3 of 20 in Ibiaku Ntok Okpo, and 2 of 15 in Umuohuodi) mentioned “due to old stems” and “poor quality of cassava stems” as reasons. Farmers did not mention disease infestation or other reasons that would indicate a degeneration of seed in the individual interviews nor in the FGDs.

The major off-farm source across all study sites is RFN (Table 5 and Figure 2). According to interviewed farmers, it is normal to share seed without payment within the community. They explained that this is rooted in the culture of cassava farming in Nigeria; but in some places this custom has changed over time. In Ibiaku Ntok Okpo, farmers indicated that in some parts of the community farmers are allowed to take cassava stems from fields without prior agreement with the owner as long as the stems are used for planting in one’s own fields and not for commercial purposes. In other parts of the community, it requires negotiation and possibly payments in cash or in-kind (although in-kind payments were reported only by five farmers across the whole sample). These farmers explained that they received seed in exchange for either other seed or labor on other farms.

With increasing commercialization of the cassava sector, cash transactions for sharing seed with RFN have become more common. In Ashina farmers explained that while they share with subsistence farmers in the community for free, the commercial farmers are expected to pay for the stems. Next to seed exchange with RFN, farmers across all study sites sourced stems from traders and via seed exchange schemes from ADP. In Umuohuodi the presence of the ADP was weaker than in the other study sites, with only one transaction in the study population. Instead, a larger share of cassava stems was sourced from traders and the local market (LM) (0.25 and 0.18 transactions/farmer, respectively). In Ashina, where many farmers source from ADP (0.14 transactions/farmer), traders had a relatively small share of the seed market (0.04 transactions/farmers).

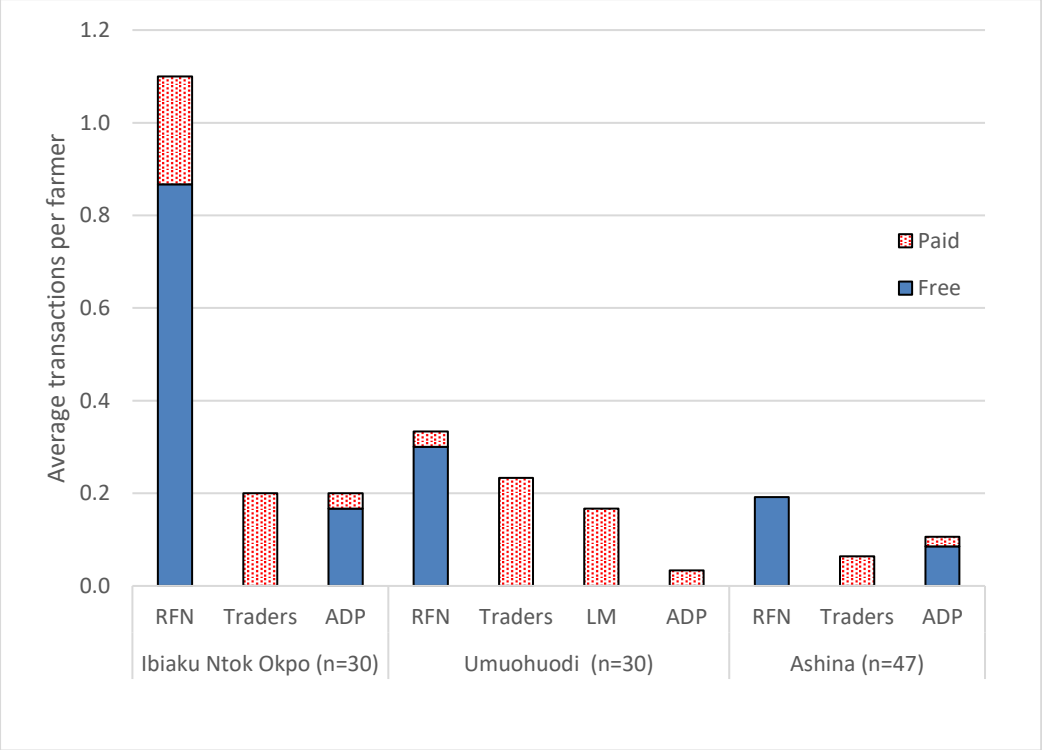

Figure 2: Average number of seed transactions per farmer in the last 12 months per site and source.

Sharing seed is common across farmers from all study sites (Table 6). Data from our survey show that although these farmers commonly shared seed within communities free of change, larger transactions are mostly paid for in cash. Farmers in Umuohuodi indicated that they share cassava stems with business partners from other communities. These traders buy from the LM and from individual farmers and ask for specific varieties, such as 'Abeokuta' and 'Nwaocha'. In Ashina and Ibiaku Ntok Okpo, sharing seed was facilitated by ADPs, in which farmers were requested to share seed with other farmers after receiving new varieties from the program.

Table 6. Sharing of cassava planting material by farmers across all study sites in the past 12 months

Study site	Farmer category	Farmers who shared seed (%)	Mean transact./ farmer (SD)	Paid trans-actions (%)	Trans-actions to RFN (%)	Trans-actions to ADP (%)	Trans-actions to traders (%)
Ibiaku Ntok Okpo	Small (N=10)	80	1.8 (0.7)	21	100	0	0
	Medium (N=11)	100	2.1 (0.7)	9	100	0	0
	Large (N=9)	100	1.7 (0.7)	13	100	0	0
Umuohuodi	Small (N=9)	89	2.8 (1.4)	18	82	0	18
	Medium (N=14)	86	2.5 (0.9)	17	83	0	17
	Large (N=7)	100	3.1 (1.2)	23	77	0	23
Ashina	Small (N=9)	89	1.4 (0.7)	9	91	9	0
	Medium (N=26)	81	1.6 (0.9)	6	94	6	0
	Large (N=12)	10	1.6 (0.8)	1		0	0

A comparison of data from seed sourcing and seed sharing indicates that, although a large share of farmers exclusively source from their own fields (Table 5), most farmers (80–100%) share seed with several other farmers in the community (1.4–3.2 transactions/farmer). This information shows that the selected farmers in the survey are "net sharers" of cassava seed. The effect is most visible in Ashina, where about 80–90% of farmers exclusively use planting material from their own field and about 80–100% of farmers share seed with RFN and ADP. In FGDs some farmers indicated that they engage in seed trade and some have created profitable businesses with stem trade in the community. Our data show that in Ashina the "net recipients" of cassava seed, who require plating material from others, were absent in the survey sample as well in FGDs.

DISCUSSION AND CONCLUSION

The cassava seed system. The cassava seed system in Nigeria consists of multiple actors, interrelations, and multidirectional seed flows. Carrying out a pre-study and a multistakeholder workshop in which results were discussed enabled our study team to identify most influential actors and seed flows in this system. Although this rapid assessment could not deliver in-depth data, the diagnosis provided valuable insights into the diversity of the cassava seed trade. A comparison of different study sites showed that agro-ecological conditions and cultural preferences not only shaped farmers' behavior for selecting varieties, sourcing, and sharing planting material. They also resulted in the emergence of trading structures, such as specialized cassava seed markets in Benue State and Ibiaku Ntok Okpo. And though the existence of these seed markets in many places of Nigeria was reported in the multistakeholder meeting, the study of farmers' seed-sourcing behavior also showed that a considerable number of stems in Umuohuodi were actually sourced from the local market. This situation is also reflected in a cassava monitoring study, which reported that 6.8% of stems in the

North, 5.2% of stems in South South, and 12.8% of stems in South East are bought on the "cassava market" (Wossen et al., 2017). An analysis of multiple channels for seed sourcing in the study communities suggests that the absence of ADP in Ibiaku Ntok Okpo and Umuohuodi created a gap that was filled by informal traders. This shows the dynamics of interconnected local and formal seed systems (Almekinders, Louwaars and de Bruijn, 1994; Coomes et al., 2015; McGuire and Sperling, 2016) and farmers adapting to seed market structures by making use of multiple delivery channels (McGuire and Sperling 2013).

Social differentiation. Out of the three study sites we found clear differences between the farmer categories only in Ibiaku Ntok Okpo. There, the intensity of off-farm seed sourcing increases from large farmers to small. Wossen et al. (2017) found a similar pattern and explained this effect by the amount of available stems on farmers' fields. Sperling and McGuire (2010) found a significantly higher share of poorer farmers sourcing seed of different crops and in different African countries from informal markets. They explained this by poorer farmers being dependent on off-farm sourcing due to a shortage of seed, whereas richer farmers engage in these markets only if they are looking for new varieties. In Umuohuodi and Ashina, the three farmer categories did not show a significant pattern of variety use, seed sourcing, or seed-sharing behavior. Owing to the availability of larger areas of land and possibly less intensified cassava production in those study sites, the described effect of "small farmers running out of stems" might not appear. Therefore, in such a context our approach of using the three defined farmer categories did not capture the socially differentiated seed use. Another aspect that stands out is the enlarged presence of "net sharers" of cassava stems in Ashina and to a lesser extent in the other study sites. This indicates that our sampling strategy did not include "net recipients" of cassava stems, who presumably depend on off-farm sourcing.

Use of different varieties and preferences. As found by Nuijten and Almekinders (2008), variety-naming by farmers can result in different names for one variety in use and possibly multiple varieties with the same names. We observed that farmers used multiple names for the same variety, such as 'TME-419'/'Long John' and '6-Months'/'Give Me Chance' in Ibiaku Ntok Okpo. The case of referring to multiple varieties with one name was not observed in our study. However, because we did not use genetic fingerprinting, we cannot be completely sure which names the reported varieties in use actually corresponded to. Although there remains some level of uncertainty on variety identification, we can conclude that the three study sites differ strongly in the varieties that farmers grow. In Ashina and Ibiaku Ntok Okpo, farmers grow older—presumably well-adapted—varieties and combine them with varieties that have been released relatively recently. Some farmers reported gradually disusing older varieties that were replaced with new and better performing ones. Umuohuodi, in contrast, is characterized by the use of landraces and disconnected from varieties that have been introduced by formal actors in the seed system since the 1970s. Although traders have contributed to the influx of varieties in Umuohuodi, farmers did not adopt or try cassava varieties that were released recently. This could indicate a lack of improved germplasm that meets the demands of farmers in this community. The limited access to germplasm and slow varietal turnover could also indicate a low degree of innovation in the seed system due to regulatory reforms (Spielman and Smale 2017). Both conditions provide entry points for seed interventions, such as BASICS.

Farmers in all study sites use a mix of varieties that is maintained due to various desired traits that are not available in a single variety alone. Depending on the specific conditions of cassava farming and use of roots, farmers valued short maturity for early harvest, long storage of roots in the soil, bitterness as a protection against rodents, and high starch content for preparation of fufu. The prevailing mix of varieties used in all study sites reflects varietal choices that are adapted to agro-ecological conditions, cultural preferences, and existing market opportunities (Bentley et al. 2017; Pircher et al. 2013; Tadesse et al. 2017). Farmers in all study communities expressed interest in trying out new cassava varieties, similar to those reported by Bentley et al. (2017). Although the social differentiation of farmers at the three study sites did not show different patterns of diffusion, farmers in Ibiaku Ntok Okpo indicated that new varieties are first grown by larger farmers and then shared with others in the community. Similar diffusion patterns and seed-sharing behavior from wealthier farmers to poorer were also observed by Almekinders and Ronner (2016) and Tadesse et al. (2016). Deeper insights into the flows of varieties within the study communities would, however, require further study and a targeted approach for the tracing of seed.

Off-farm seed sourcing. The majority of interviewed farmers sourced the largest part of cassava planting material from their own fields (62–97% of the stems used across study sites). Predominant seed sourcing from own farms was also found in other studies on cassava (Kansiime and Mastenbroek 2016; Lynam, unpublished manuscript). Nevertheless, a considerable amount of farmers in all study sites sourced seed off-farm, as also described by other studies on cassava (Kansiime and Mastenbroek 2016; McGuire and Sperling 2016). Degeneration was not a driver for the interviewed cassava farmers to source seed from RFN, ADP, and traders. This can be explained by the absence of crop diseases that can cause stem degeneration. The largest threat to cassava production is cassava brown streak disease, which is currently present in east and central Africa but has not yet affected west Africa (Patil, Legg, Kanjuand Fauquet 2015). Most important factors for off-farm seed sourcing were the interest in new varieties and the shortage of seed on farmers' own fields. The limited storage period of cassava planting material seems to be an important factor in the latter. Cassava farmers in Ghana indicated a maximum storage period of 7–8 weeks, depending on the type of storage (Osei, Taah, Berchieand Osei 2009). Farmers in this study use adapted technologies for seed storage and harvest their crop piecemeal (which results in continuously having cassava plants on their fields) in order to source planting material from their own farms. Yet others depend on additional seed sources such as RFN and, to a smaller extent, from traders. Depending on social norms and ties between farmers, these transactions are paid for, in-kind, or free of charge—findings similar to those on the acquisition and distribution of sweetpotato vines in Tanzania (Adam et al. 2018).

Implications for the BASICS project. The study shows an examination into the formal and informal seed system identified important entry points of BASICS VSEs. First, there was a widespread interest of farmers in trying out new cassava varieties and finding varieties that meet multiple preferences of farmers. Second, the demand for planting material is strong due to a shortage of seed.

Farmers in all study sites use a mix of varieties in which they combine multiple traits (e.g., short maturity for early harvest, long storage of roots in the soil, bitterness as a protection against rodents, and high starch content for preparation of fufu). These farmers request specific varieties to add further traits to their current

mix of varieties. Their demand for new cassava varieties therefore depends highly on the local context, preferences, and varieties that are already in use. To ensure the provision of varieties demanded by their clients, the VSEs need to be empowered to influence early-generation seed producers. Demonstration plots, accessible by farmers in the vicinity where they can compare varietal traits and select varieties to test on their own fields, create an opportunity for exposure (Bentley et al. 2017).

Larger amounts of stems sales and long-term profits can be realized by tapping into the market of cassava seed that farmers buy due to the seasonal shortage of planting material. As argued above, small farmers might be more likely to run out of planting material than farmers with larger cassava fields. The demand for stems is currently covered by (paid) seed exchange between RFN, traders, and seed markets, with stem trade facilitated by ADP. Informal traders have established and manage profitable cassava seed enterprises. Offering certified seed that is true to variety would be a value proposition of traders to their clients. Enabling informal traders to sell certified seed could be realized either by integrating them into the formal seed value chain as VSEs or by acting as seed distributors in partnership with VSEs. Advanced knowledge of the multiple informal actors and institutions is needed to establish a collaboration that creates mutual benefits and assures co-existence of VSEs and informal seed actors in the system.

Further research. The explorative character of this study opened up two issues that require further research. Studying social differentiation with a survey of different farmer categories gave us insights into the social structure; however, it did not fully explain the social dynamics in the three study communities. This understanding is essential to create a profile of (recurrent) stem buyers who have the purchasing power to buy from VSEs. In-depth research on social differentiation and local dynamics of cassava farmers and the associated seed-sourcing behavior is needed to complement and explain further the findings of this study. Studying the cassava seed system and farmers' seed-sourcing behavior showed that informal seed traders can play an important role in the seed system by, for example, substituting the lack of formal structures. In addition, Rachkara et al. (2017) and Sperling and Mcguire (2010) emphasize the untapped potential of traders in the seed system. For projects like BASICS, it is crucial to understand the dynamics and different actors in informal seed trade and harmonize the establishment of and support to decentralized seed multipliers within existing structures.

LITERATURE

Adam, R. I., Badstue, L.and Sindi, K. 2018. The dynamics of smallholder farmers' acquisition and distribution of sweetpotato vines in the Lake Victoria Zone Region, Tanzania. *Food Security 10*, 339–350. https://doi.org/10.1007/s12571-018-0776-5

Alene, A.D., Abdoulaye, T., Rusike, J., Manyong, V.and Walker, T.S. 2015. The effectiveness of crop improvement programmes from the perspectives of varietal output and adoption: Cassava, cowpea, soybean and yam in sub-Saharan Africa and maize in West and Central Africa. In *Crop Improvement, Adoption, and Impact of improved varieties in Food Crops in Sub-Saharan Africa*.

Almekinders C., Pircher T., O. D. 2017. *Multi-stakeholder workshop on cassava seed system in Nigeria, Report of a workshop on November 10 2017*. Umudike, NRCRI.

Almekinders, C.J.M., Louwaars, N.P.and de Bruijn, G.H. 1994. Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica 78*(3):207–216. https://doi.org/10.1007/BF00027519

Almekinders, C.J.M., Walsh, S., Jacobsen, K.S., Andrade-Piedra, J.L., McEwan, M.A., de Haan, S. and Staver, C. 2019. Why interventions in the seed systems of roots, tubers and bananas crops do not reach their full potential. *Food Security*, *11*(1):23–42. https://doi.org/10.1007/s12571-018-0874-4

Almekinders, C.and Ronner, E. 2016. *Tracing seed diffusion from introduced legume seeds through N2Africa demonstration trials and seed-input packages N2Africa Putting nitrogen fixation to work for smallholder farmers in Africa*. Retrieved from www.N2Africa.org

Bentley, J., Olanrewaju, A., Madu, T., Olaosebikan, O., Abdoulaye, T., Assfaw Wossen, T. and Tokula, M. 2017. *Cassava farmers' preferences for varieties and seed dissemination system in Nigeria: gender and regional perspectives*. Ibadan, Nigeria: IITA Monograph.

Coomes, O.T., McGuire, S.J., Garine, E., Caillon, S., McKey, D., Demeulenaere, E., … Wencélius, J. 2015. Farmer seed networks make a limited contribution to agriculture? Four common misconceptions. *Food Policy*. https://doi.org/10.1016/j.foodpol.2015.07.008

FAOSTAT. 2017. http://www.fao.org/faostat/en/ accessed on 20/12/2017

GoN. 2012. *Draft Action Plan for a Cassava Transformation in Nigeria*. Retrieved from https://www.unaab.edu.ng/attachments/Cassava Report Final.pdf

Kansiime, M.K.and Mastenbroek, A. 2016. Enhancing resilience of farmer seed system to climate-induced stresses: Insights from a case study in West Nile region, Uganda. *Journal of Rural Studies 47*:220–230. https://doi.org/10.1016/J.JRURSTUD.2016.08.004

McGuire, S. and Sperling, L. 2013. Making seed systems more resilient to stress. *Global Environmental Change 23*(3):644–653. https://doi.org/10.1016/J.GLOENVCHA.2013.02.001

McGuire, S.and Sperling, L. 2016. Seed systems smallholder farmers use. *Food Security 8*(1):179–195. https://doi.org/10.1007/s12571-015-0528-8

Nuijten, E.and Almekinders, C.J.M. 2008. Mechanisms explaining variety naming by farmers and name consistency of rice varieties in The Gambia. *Economic Botany*, *62*(2), 148–160. https://doi.org/10.1007/s12231-008-9012-0

Oparinde, A., Abdoulaye, T., Manyong, V.M., Birol, E., Asare-Marfo, D., Kulakow, P. and Ilona, P. 2016. A technical review of modern cassava technology adoption in Nigeria (1985-2013): Trends, challenges, and opportunities. *HarverstPlus Working Paper*, *22*(December), 1–24. Retrieved from http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/130268

Osei, M., Taah, K., Berchie, J.and Osei, C. 2009. A Survey of cassava (Manihot esculenta Crantz) Planting Materials in Storage: A case study in two communities in the Ejisu district of Ashanti region, Ghana.

Journal of Agronomy, *8*(4):137–140. Retrieved from http://docsdrive.com/pdfs/ansinet/ja/2009/137-140.pdf

Patil, B.L., Legg, J.P., Kanju, E.and Fauquet, C.M. 2015. Cassava brown streak disease: A threat to food security in Africa. *Journal of General Virology*, *96*(5), 956–968. https://doi.org/10.1099/vir.0.000014

Pircher, T., Almekinders, C.J.M. and Kamanga, B.C.G. 2013. Participatory trials and farmers' social realities: Understanding the adoption of legume technologies in a Malawian farmer community. *International Journal of Agricultural Sustainability*, *11*(3):252–263. https://doi.org/10.1080/14735903.2012.738872

Rachkara, P., Phillips, D.P., Kalule, S.W. and Gibson, R.W. 2017. Innovative and beneficial informal sweetpotato seed private enterprise in northern Uganda. *Food Security*, *9*(3), 595–610. https://doi.org/10.1007/s12571-017-0680-4

RTB (CGIAR Research Program on Roots, Tubers and Bananas). 2016. *Multi-stakeholder framework for intervening in RTB seed systems* (No. ISSN 2309-6586). Lima, Peru.

Sperling, L. and McGuire, S. 2010. Understanding and strengthening informal seed markets. *Experimental Agriculture*, *46*(2), 119–136. https://doi.org/10.1017/S0014479709991074e

Spielman, D.J.and Smale, M. 2017. *Policy options to accelerate variety change among smallholder farmers in South Asia and Africa South of the Sahara; IFPRI Discussion Paper 01666*. Retrieved from http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/131364/filename/131575.pdf

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O. and Struik, P.C. 2016. Tracing the seed: Seed diffusion of improved potato varieties through farmers' networks in Chencha, Ethiopia. *Experimental Agriculture*, *53*(4), 1–16. https://doi.org/10.1017/S001447971600051X

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O.and Struik, P.C. 2017. Understanding farmers' potato production practices and use of improved varieties in Chencha, Ethiopia. *Journal of Crop Improvement*, *31*(5), 673–688. https://doi.org/10.1080/15427528.2017.1345817

Tahirou, A., Bamire, A.S., Oparinde, A.and Akinola, A.A. 2015. Determinants of adoption of improved cassava varieties among farming households in Oyo, Benue, and Akwa Ibom states of Nigeria. *HarverstPlus Working Paper*, *22*(December), 21.

Wossen, T., Girma, G., Abdoulaye, T., Rabbi, I., Olanrewaju, A., Alene, A., … Manyong, V. 2017. *The cassava monitoring survey in Nigeria final report*. Ibadan, Nigeria. Retrieved from www.iita.org

RESEARCH PROGRAM ON Roots, Tubers and Bananas

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