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Pioneering commercialization of certified cassava seed production: Impacts on sustainable cassava production, income and wealth creation in Uganda

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Abstract Cassava is one of the most important food crops and sources of income for Uganda's smallholder farmers. However, yields are low due to diseases like cassava brown streak and cassava mosaic, poor quality of planting materials used and declining soil fertility, among other factors. To address the challenge of poor quality planting materials, a program aimed at establishing a functional cassava seed system to monitor production and marketing of certified cassava seed was implemented. This study evaluated the impacts of this intervention on certified cassava seed multipliers and sellers (CSEs) and smallholder farmers (SHFs) in Uganda. A survey was conducted to assess the benefits of inspection and certification to CSEs, CSEs willingness to pay for inspection and certification services, farmers' access status to clean planting materials of improved cassava varieties, and farmers' yields and income. Majority of CSEs (74%) reported planting, production and marketing of high-quality planting materials as main benefit of inspection and certification, followed by improved knowledge on cassava crop management (67%), and better prices for certified planting materials (56%). A bigger proportion of CSEs (63%) reported the willingness to pay for inspection and certification costs, with majority (56%) willing to pay USD 11-20 per inspection. Forty percent of SHFs reported increased access to improved planting materials which was attributed to community-based cassava seed multiplication fields established by CSEs in the areas. Additionally, 80 and 47% of CSEs and SHFs, respectively, reported increased yields from planting clean planting materials, and this was associated with improved household income. The study shows positive impacts of the intervention towards creating a functional cassava seed system. However, farmers reported high costs for clean planting materials from CSEs. Therefore, to make the seed system efficient and sustainable, deliberate efforts should be made to ensure farmers affordably access planting materials for sustainable cassava production.

Keywords: Certified cassava seed, Cassava seed entrepreneurs, Smallholder farmers, Inspection and certification, Functional cassava seed system, Sustainable cassava production

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Introduction

Cassava (*Manihot esculenta* Crantz) is considered a major staple food and cash crop of over 800 million people globally, the third most important source of calories in the tropics after rice and corn, and accounts for a third of the total food produced in the Sub-Sahara Africa (Virtual Livelihood School Africa, VLSA-Uganda, 2014; Ijala *et al*., 2017). In Uganda, cassava is one of the most important food crops ranked second to bananas, grown by over 75% of all farm households, providing around 13% of the daily calorie intake and, the main source of income for smallholder farmers especially women, contributing up to 22% of cash incomes from all food crops, second only to maize (Uganda Bureau of Statistics, UBOS and Ministry of Agriculture, Animal Industry and Fisheries, MAAIF, 2010; VLSA, 2014). Cassava therefore is a crop that can be used to attain some of the sustainable development goals in particular, the eradication of extreme poverty and hunger. Despite its importance, cassava yield in Uganda is still very low, averaging 12 t/ha compared to yield potential of 30t/ha reported on research stations (National Agricultural Research Organization, NARO, 2014). The major reasons for these wide yield gap have been attributed to poor quality of planting materials used by farmers, scarcity of clean planting materials of high yielding varieties, ravages by pests and diseases mainly cassava brown streak disease (CBSD) and cassava mosaic disease (CMD), and declining soil fertility (National Crops Resources Research Institute, NaCRRI, 2014). Therefore, to sustain cassava's double role for food and income uses, these production constraints must be addressed in order to attain sustainable optimal productivity and increased incomes by smallholder farmers.

The scarcity of clean planting materials for disease-resistant high yielding cassava varieties poses a threat to the livelihoods of smallholder farmers dependent on the crop for food and income. Scarcity of planting materials is reported as the major constraint to higher productivity of cassava at farm level (Ralph and Magado, 2011; NARO, 2014). Although efforts have been made to breed better yielding and disease resistant varieties, the traditional private seed companies have not pursued them. Yet, cassava has gained more attention as a food security crop, due to its ability to survive in more challenging growing environments (NARO, 2014). This inadequate supply of quality planting materials and absence of a formal seed sector is a serious concern for those involved in the cassava value chains. Cassava, like other vegetatively propagated crops, does not benefit from the formal seed systems that include certification protocols and standards. In an effort to develop and operationalize inspection and certification protocols and standards, the cassava seed system project was implemented from 2013 up to 2017 with the aim of establishing a

functional seed system for cassava, where specific certification protocols and standards are followed and qualified cassava fields are certified for sale as seed to enable efficient and commercially viable distribution of quality cassava planting materials to farmers for production. The project was implemented by both government and private institutions as well as NGOs. National Crops Resources Research Institute, a public agricultural research institute, under the policy guidance of NARO lead the project. Africa Innovations Institute and CHAIN-Uganda, both NGOs, were engaged to ensure that cassava seed entrepreneurs (CSEs) have access to clean basic seed that they can multiply and profitably sell to farmers and other buyers. BioCrops-Uganda, a private tissue culture laboratory was responsible for mass propagation of disease free planting materials for establishment of pre-basic seed fields and, the National Seed Certification Services (NSCS) of MAAIF being responsible for the regulation, inspection and certification of basic and certified cassava seed. Cassava seed entrepreneurs by definition were farmers (small, medium and large scale) who engaged in cassava planting material multiplication as a business, some of whom had been multiplying cassava stems informally, where no inspection and certification was done.

This study therefore assessed the impacts of the project intervention (inspection, certification and marketing of certified cassava planting materials) on CSEs and smallholder farmers in eastern, northern and central Uganda where Africa Innovations Institute implemented the project activities. The research questions for this study were: Do CSEs find any benefits from inspection and certification of their cassava seed multiplication fields? Are CSEs willing to pay for inspection and certification of their cassava multiplication fields after the project intervention? Do smallholder farmers have more access to clean (certified) cassava planting materials as a result of the established cassava multiplication fields in their areas?

The objectives were to (i) assess the benefits of inspection and certification to CSEs (ii) assess the willingness of CSEs to pay for inspection and certification services (iii) evaluate the status of smallholder farmers' access to clean cassava planting materials and, (iv) assess the yield and income benefits (by the smallholder farmers and CSEs) of planting clean planting materials of improved cassava varieties.

Materials and Methods

Study site

The study was conducted in purposively selected districts in Teso sub-region (eastern), Lango sub-region (northern) and central region where the

cassava seed system project was being implemented. The survey was specifically conducted in the districts of Amuria, Ngora and Soroti for Teso sub-region; Apac, Lira, Otuke and Oyam for Lango sub-region; and Nakaseke and Kiryandongo for central region. The study was conducted between October, 2016 and January, 2017.

Sampling and sample size

Sampling for CSEs was purposive targeting only those CSEs who had gone through a complete crop cycle, had their fields inspected, certified or uncertified, and had sold certified cassava seed. A total of 27 CSEs distributed across the study area were interviewed out of 33 CSEs who were eligible to participate in the study because they had a complete crop cycle and had sold certified seed. For the smallholder farmers, a multi-stage random sampling technique was used to identify respondents. Households were selected from 3 sub-counties within each district irrespective of whether they are near or far away from the established cassava multiplication fields in the area. Equal numbers of households were sampled from each district, with a total number of 189 households interviewed in the nine districts where the survey was conducted i.e. 7 households from each sub-county, giving a total of 21 households from each district). At the sub-county level, the respondents were selected at least from two parishes with at least two villages from each parish.

Source of information and Data collection

Information related to CSEs was collected from either the CSE his/herself or from the manager who is considered the custodian of most of the information regarding the cassava seed business enterprise. For the smallholder farmers, information was collected from a family member taking most of the decisions on farming activities (household head) or household representative and/or spouse, but information was cross-checked with other family members, where necessary. Structural questionnaires were administered to both CSEs and smallholder farmers within their homesteads and the enumerator helped validate some of the information collected. Statistical analysis for all the data collected was done using SPSS for Windows (Version 18.0).

Results

Benefits of inspection and certification to CSEs

The benefits of inspection and certification reported by CSEs included planting, producing and marketing high quality planting materials; easy

marketing of the planting materials due to assured quality by buyers; better prices offered for the planting materials and; improved knowledge on crop management especially on agronomy, disease identification and management. Most of the CSEs (74.1%) reported production and marketing of high quality planting materials as a key benefit of inspection and certification, and 66.7% reporting improved knowledge on crop management due to inspection (Figure 1). In addition, 55.6% of the CSEs reported that they sold their planting materials at much better prices as a result of inspection and certification. The benefit of ease in marketing of the planting materials that CSEs reported is realized as a result of buyers being assured of the quality of the planting materials they are buying.

Figure 1. Benefits CSEs get when their cassava seed multplication fields are inspected and certified by NSCS

Willingness of CSEs to pay for inspection and certification of their seed fields

The study revealed that 63.0% of CSEs were willing to pay for inspection and certification costs (Figure 2), with majority (96.3%) willing to pay between USD 11 – 30 (UGX 40,000 – 100,000) per inspection while the rest of the CSEs reported willingness to pay more than USD 30 per inspection (Table 1). The amount paid according to CSEs depended on where the inspectors come from (.i.e. within the district or NSCS headquarters), irrespective of the field size for inspection.

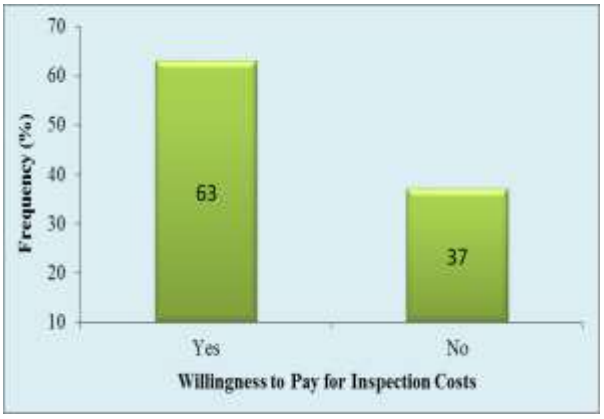

Figure 2. CSE willingness to pay for the cost of inspection and certification after the project intervention

Table 1. Amount of money (USD) CSEs are willing to pay for inspection of their cassava seed multiplication fields

Amount to pay (USD)	Frequency (%)
1.0 - 10.0	0
11.0 - 20.0	55.6
21.0 - 30.0	40.7
31.0 - 40.0	3.7
41.0 - 50.0	0
Total	100

Smallholder farmers' access to clean cassava planting materials of improved varieties

The study showed that approximately 40% of smallholder farmers had increased access to clean planting materials of improved cassava varieties while majority of the smallholder farmers did not experience any improvement to access of improved cassava planting materials (Figure 3). The improved access to clean planting materials of improved cassava varieties was attributed mainly to the community-based cassava seed multiplication fields established by CSEs within the areas. Since CSEs were farmers within the location of the respondents, majority of the respondents (66.8%) who reported increased access to planting materials of improved cassava varieties showed that their

main source of planting materials was from fellow farmers (Table 2). Other sources of improved varieties were from own fields planted with improved variety that was sourced either from fellow farmers the previous season or provided by government extension agents or NGO.

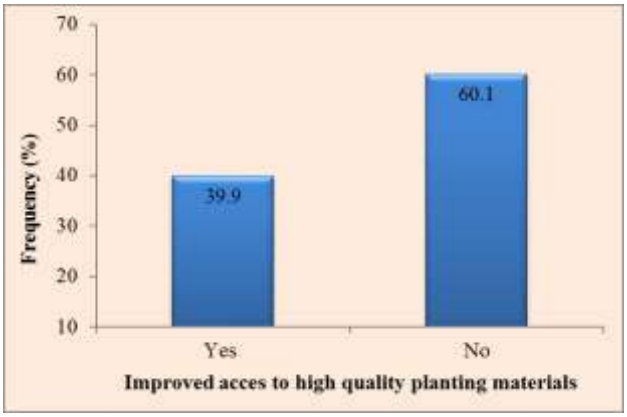

Figure 3. Access to high quality planting materials of improved cassava varieties by smallholder farmers

Table 2. Sources of planting materials of improved cassava varieties by smallholder farmers

Sources of cassava planting materials	Frequency (%)
Fellow farmers (CSEs)	34.6
Fellow farmers (others with improved varieties)	32.2
Own field/farm	15.7
Government extension agents	9.1
NGO	5.6
Research institute	2.8

Although approximately 35% of the smallholder farmers who reported improved access to planting materials of improved cassava varieties (Table 2) had accessed the planting materials from CSEs, the study, however, revealed that the prices charged per bag of the certified planting materials (USD 7 - 14) are high for many smallholder farmers, making them resort to planting any available materials whether improved or local variety. One respondent noted "because I was unable to pay the price each bag of the planting material costs, I

had to plant materials from my previous field yet, I am located near to the certified seed field". Respondents who noted that prices for the certified planting materials were higher and could not afford, resort to planting any cassava planting materials they access, irrespective of the variety, source and quality.

Benefits of using clean planting materials of improved cassava varieties to smallholder farmers and CSEs

The study indicated that 47% of the smallholder farmers (Table 3) who had reported access to high quality planting materials of improved varieties noted an increase in fresh root yields when compared to yields obtained from gardens planted with materials of unknown quality. The increase in root yields was associated with increase in household income from the sales of fresh roots and or processed cassava. For CSEs, 80% reported increase in root yields (Table 3) as well as increased incomes from sale of stem cuttings (certified seed), fresh roots and or processed cassava. For instance, one CSE stated "I used to sell cassava roots to a tune of USD 250 – USD 420 per season but this time I have been able to sell fresh roots up to a tune of USD 790 from the same area of land in a season". Another CSE reported "I sold the processed cassava flour worth USD 1,641 after a season's harvest, which was three times what I used to get".

Table 3. Yield increase by smallholder farmers as a result of using high quality planting materials of improved cassava varieties

Parameter	Category	Response	Frequency (%)
Have you realised any yield increase from using high quality planting materials?	SHFs	Yes	47.2
		No	52.8
	CSEs	Yes	80.4
		No	19.6

SHFs - smallholder farmers

Discussion

Benefits of inspection and certification to CSEs

Planting, producing and marketing high quality planting materials; improved knowledge on cassava crop management; better prices offered for the

certified planting materials produced and; easy marketing of the planting materials were the benefits reported by CSEs. The main benefit of high quality planting materials production and marketing reported by CSEs is attributed to the constant inspection of multiplication fields by district and NSCS inspectors to ensure seed multipliers adhere to the standards and protocols in certified seed production. With the regular inspection, CSEs are always advised accordingly on best management practices for their seed fields including timely weeding, identifying diseased or infested crops and how to manage such crops hence, improving their knowledge on crop management thus resulting to well managed crop fields free of weeds, pests and diseases that would lower the quality of the planting materials. Because of the high quality of planting materials produced, CSEs noted that they were able to sell their materials at higher prices compared to the prices they could charge for planting materials from uninspected fields. These findings clearly indicate a positive impact by the project towards creating awareness on production, marketing and planting of high quality planting materials. The study findings are supported by a report of Kyamanywa *et al*. (2011) which indicated that to better harness improved and sustainable cassava production as a food security crop in the face of the changing climate, there is need to develop and promote well suited cultivars supported by efficient seed multiplication and delivery systems where, high quality planting materials are produced and sold or delivered to farmers. However, Louise *et al*. (2013) observed that scaling the adoption of improved varieties and quality seed among smallholder farmers must include both formal and informal seed systems, further noting that in vegetatively propagated crops, an integrated seed system would be the main driver for seed system impact and scaling up.

The fact that CSEs reported selling their materials at higher prices and easily is supported by Gildemacher *et al*. (2017) who stated that external quality assurance is a service for seed customers when judging the quality of the seed they intend to buy and use; further observing that the most important basis for seed customers to buy seed from specific seed producer is the reputation of the producer. Since farmers' productivity depends on the quality of the seed used, an additional safeguard through inspection and certification of seed fields to ensure that the seed purchased by farmers (other seed customers) is of good quality, matters a lot. However, Gildemacher *et al*. (2017) noted that seed producers benefit from well-functioning external quality assurance not to assist them in producing good quality seed, which is their own responsibility, and for which they need good internal quality control, but to prove the quality of their planting materials to their customers.

Willingness of CSEs to pay for inspection and certification costs

The study found high willingness of seed producers (CSEs) to pay for inspection and certification costs. The high willingness is attributed to the benefits CSEs get when their seed fields are inspected and certified. As a result of such benefits, CSEs are willing to pay a modest fee for inspection and certification, as shown by the amount majority are willing to pay. Gildemacher *et al*. (2017) conquer with this finding as they noted that, farmers are willing to pay for external quality assurance when the additional cost of inspection and certification is modest compared to the profits they can obtain from the crop. The finding indicated a positive step towards establishing a functional cassava seed system since cassava seed multipliers see added value in inspection of their fields and willing to meet the inspection and certification costs. Though, Louise *et al*. (2013) observed that farmers' demand for particular varieties was the principle determinant of success in establishing seed system for vegetatively propagated crops. However, farmers' demand for particular cassava varieties, in the case of Uganda, is not a challenge as different varieties are promoted in different parts of the country depending on the need and demand of the area.

Smallholder farmers' access to clean cassava planting materials of improved varieties

Result showed that about 40% of smallholder farmers had increased access to high quality planting materials of improved cassava varieties, with majority still having poor/limited access to high quality cassava planting materials. The finding indicates the need for more seed multiplication fields uniformly distributed within the regions to provide easy and equitable access to clean planting materials. To ensure sustainability of cassava productivity, farmers need to timely access these high quality planting materials, which is possible when community-based seed multiplication fields are located near to the farmers. According to FAO (2013), the potential of cassava and its sustainable production can only be realized when production constraints are mitigated for high yielding varieties, and cassava growers have reliable and timely access to disease-free planting materials. The availability and use of high quality planting materials that are free of diseases and pathogens are crucial for sustainable intensification of the cassava production systems (FAO, 2013; Centro Internacional de Agricultura Tropical – CIAT, 2015).

However, smallholder farmers noted a high price for certified planting materials, implying that, for sustainability of a functional cassava seed system, efforts must be put towards ensuring that certified planting materials are available to farmers at affordable prices. According to Gildemacher *et al*. (2017), smallholder farmers usually adhere to an economic strategy of risk

avoidance. Investing in seed of an assured quality greatly reduces risk but at the same time, the monetary investment required increases the risk. As such, for planting materials of crops used strictly for home consumption, farmers are not willing to pay a high premium for quality seed of these crops, even when they see a clear difference in the yield potential of the quality seed and that of their own seed (Gildemacher *et al*., 2017). This would call for deserted efforts to make sure that certified planting material costs are as low as possible for ease of affordability by the smallholder farmers to sustain a functional cassava seed system, and cassava productivity.

Benefits of using clean planting materials of improved cassava varieties to smallholder farmers and CSEs

The study showed that 47 and 80% of the smallholder farmers and CSEs, respectively, reported increase in yields as a result of using high quality planting materials of improved cassava varieties. The increase in root yield was associated with increase in household income from the sales of fresh roots or processed cassava for both SHFs and CSEs and, additional incomes from sales of certified seed by CSEs. These findings were in agreement with Amao and Awoyemi (2008), Abdoulaye *et al.* (2013), Acheampong and Owusu (2015), Afolami *et al.* (2015) and Khonje *et al.* (2015) who reported higher cassava yields as well as increased household incomes from farmers who had adopted improved cassava varieties in Ghana, Nigeria and Zambia. These findings clearly showed the potential of having a functional cassava seed system in sustaining the livelihoods of the cassava growing communities when high quality planting materials are used. The use of quality planting materials of improved varieties would enable sustainable cassava production for a sustainable household food and income security, as Acheampong and Owusu (2015) and Khonje *et al*. (2015) showed that improved cassava varieties had significant potential impacts on household poverty reduction. Similarly, Anna *et al*. (2010) noted that cassava had the potential to help many households achieve food security in a sustainable manner, especially, in the face of the changing climate.

However, a lower proportion of SHFs (47%) reported increase in root yields compared to a bigger proportion of CSEs (80%) who reported increase in yields. The lack of achieving high yields by majority of SHFs who planted high quality cassava planting materials could be attributed to poor field management practices, especially, planting time, lack of proper spacing to attain optimum plant population per unit area and weeding time. As a result, the use of high quality planting materials of improved varieties still did not help to achieve

high yields. As mentioned by Leihner (2002), Reinhardt (2002), Anna *et al.* (2010), Fermont *et al*. (2010) and Adebayo *et al*. (2014), the yield potential of cassava cannot be realized with poor agronomic practices even where a substantial yield increase could be achieved. Thus, SHFs using high quality planting materials with poor agronomic practices would not realize higher yields. In contrast, CSEs who adhered to proper spacing and weeding time to satisfy field standards required for certification as a clean source of planting materials, majority achieved higher yields.

The research findings showed positive impacts of the intervention of the cassava seed system project towards creating a functional cassava seed system, as noted by the willingness of CSEs to pay for inspection and certification services and, the other benefits CSEs and SHFs derived from the interventions. The findings that both CSEs and SHFs were able to achieve more yields and incomes as a result of planting certified planting materials indicate that a functional cassava seed system would enable sustainable cassava production for a sustainable household food and income security, especially, for households dependent on the crop as a main source of livelihoods. However, it is recommended that deliberate efforts be made to ensure equitable access to the certified planting materials at affordable prices by smallholder farmers.

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