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Cluster 5.1: Forsight and Impact Assessment

Livelihood Impacts of Improved Cassava Varieties in Uganda

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Abstract

In Uganda, smallholder cassava farmers largely depend on unregulated, informal cassava seed sources that normally operate without inspection and certification. As a result, the use of latently diseased planting materials had thrived unabated in the country. However, since recently, a growing number of farmers have been using certified planting materials of improved cassava varieties (ICVs) following the establishment of a community-based commercialized seed system called the Cassava Seed Entrepreneurship (CSE) initiative. The planting materials produced by the CSE initiative are subject to inspection and certification by the mandated authorities. In this article, we seek to demonstrate whether certification of planting materials of ICVs has led to improved livelihood through increased cassava productivity. To this end, we applied the endogenous switching regression model (ESR). The data used in the study came from a representative sample of 609 households in the major cassava growing regions of Uganda. The results show that adoption of certified planting materials of ICVs has statistically significant positive effects on cassava productivity and household welfare, pointimg to the need for policy support aimed at increasing and sustaining public investments in variety genetic improvement, seed inspection and certification.

***Key words*:** Cassava, certification, adoption, productivity and household welfare, impact, endogenous switching regression, Uganda

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1. INTRODUCTION

In sub-Saharan Africa, raising agricultural productivity is considered to present an important opportunity for rapid economic growth (MFPED, 2014), contributing to poverty reduction and food and nutritional security (World Bank, 2016b). In an effort to increase agricultural productivity and improve smallholder farmers' livilihoods in the region, national and international research organizations have been implementing crop improvement programs for various crops, including cassava. The National Agricultural Research Organization (NARO) of Uganda in partnership with the International Institute of Tropical Agriculture (IITA) has been implementing different initiatives to increase cassava production and productivity in the country using the Agricultural Innovation Systems (AIS) concepts and approaches. The AIS remains the hallmark of the national cassava breeding programs, resulting in the release and dissemination of 19 cassava varieties between 2000 and 2013 (NARO, 2011, 2014). Most of the improved cassava varieties (ICVs) have been adopted in the major cassava growing regions of Uganda to varying levels ranging between 65-77 percent (Wellard et al. 2015). Yet, on-farm yields are between 8.0 t/ha and 12.0 t/ha (Fermont et al., 2009), compared to 25 t/ha reported on research stations (NARO, 2011), constituting a yield gap of 13 t/ha. One plausible explanation for the yield gap is the lack of access to quality planting materials of improved varieties. The lack of certified improved planting materials constrains smallholder farmers' ability to increase productivity (Misiko and Ramisch, 2007, World Bank 2016a, 2016b). In Uganda where the seed system for vegetatively reproduced crops is not well developed yet, smallholder cassava farmers largely depend on unregulated cassava seed supply system that normally lack protocols, standards, and guidelines (Rubyogo et al., 2007). As a result, the use of latently diseased planting materials has thrived unabated (Pariyo et al., 2015; Kumakech et al. 2013). However, since recently, a growing number of farmers have been getting access to certified cassava planting materials of ICVs. This came about following the establishment of a community-based commercialized system that operates under the supervision of the country's mandated authorities called the Cassava Seed Entrepreneurship (CSE) initiative[1]. Certified planting materials have been disseminated through intensive government seed multiplication and distribution programs, farmer cassava innovation platforms, NGO seed distribution networks, farmer initiatives and other post-war recovery programs (Wellard et al. 2015; NARO, 2014). This study seeks to investigate whether households who adopted certified ICVs perform better in terms of cassava productivity and household welfare than those who use (i) uncertified ICVs and (ii) local varieties. To the best of our knowledge, this is the first study which attempts to establish the link between adoption of certified ICVs and cassava productivity and household welfare in Uganda. To this end, we apply a rigorous econometric model, particularly the endogenous switching regression (ESR) model. The ESR model controls for all the differences in measured and unmeasured heterogeneity. Previous studies on cassava in Uganda (e.g., Bua, 1998; NRI, 2014, Wellard et al., 2015) only applied mean comparisons of outcomes of production, yields, incomes, food security and economic status. As such, our study contributes to the literature on agricultural impact evaluation in three different ways. First, unlike past studies on productivity and consumption expenditure of the adoption of improved varieties of various crops (e.g., Magrini and

[1] The CSE initiative is a research for development intervention of NARO-NaCRRI that brings together various players in the cassava seed value chain and uses AIS concepts to establish a functional commercialized cassava seed delivery system in Uganda

Vigani 2016), Khonje et al., 2015; Mmbando et al., 2014; Kuntashula & Mungatana, 2013; Asfaw et al., 2011; Kassie et al., 2011; Asfaw, 2010; Diagne et al., 2009) our study differentiates improved varieties into certified and uncertified and local varieties, thus jointly measuring the impacts of seed certification and genetic improvement on productivity and consumption expenditure. It captures the effect of both the quality and productivity of ICVs. Second, our study applies a rigorous econometric model that controls for both observed and unobserved heterogeneity concerns, thus yielding reliable empirical estimates. Third, our study uses a comprehensive and nationally representative household data from all major cassava growing regions of Uganda. To the extent that such a comprehensive analysis approach hasn't been previously applied to study the impact of cassava innovations in Uganda, we submit that our study represents original contribution to the existing body of organized knowledge on cassava in the country.

The next section presents an overview of cassava research program in Uganda, highlighting the application of AIS concepts in technical (disease-tolerant cassava varieties) and social innovations (seed systems). Section 3 presents the analyrtical framework, highlighting the specification and estimation of the ESR model. Section 4 describes the data and measurement of outcome, treatment and independent variables. Section 5 presents the results of the study, starting with the descriptive results, highlighting the differences in outcome and control variables between adopters and non-adopters of certified ICVs, followed by the results from the empirical model, focusing on the average and heterogeneous effects of the adoption of certified ICVs on cassava productivity (cassava root yield in kilograms per acre) and household welfare measured in terms of food consumption expenditure per capita (hereafter referred to as consumption expenditure).

2. Overview of cassava production, research and seed supply

2.1. Cassava production

In Uganda, cassava is the second most important staple food crop after plantains with per capita annual consumption of 101 kgs, and daily caloric intake of 300 Kcal, accounting for 13% of the total daily caloric intake (FAO, 2015b). Cassava's high productivity, tolerance to drought, suitability to intercropping with a wide range of crops, vegetative propagation and timing flexibility with harvesting makes it a suitable choice of crop for smallholder farmers' food security (Taiwo et al., 2014). As such, it holds the highest potential as a food security crop in Sub-Saharan Africa (SSA) particularly because of its unique positive attributes of high water stress tolerance levels, long soil storability and high caloric value among others (Jarvis et al., 2012). In 2014, it was prioritized by the New Partnership for African Development (NEPAD) as a "poverty fighter" (NEPAD, 2004).

In Uganda, cassava is grown on an estimated area of 871,000 ha. The latest Uganda Census of Agriculture of 2008/09 report indicates that the Eastern region is the largest producer of cassava with an estimated area of 342,387 ha followed by the Northern region with 269,886 ha and the mid-Western region with 131,328 ha. Despite their highcassava production, the regions inhabit the poor in the country grappling with the lowest agricultural productivity (World Bank, 2016b; Pariyo et al., 2015; MFPED, 2014). The national yield of cassava in Uganda is estimated to be 12-15 tones/ha. In an effort to increase the productivity of cassava, efforts have been made since the early 2000s to develop more resilient cassava varieties under AIS research framework following the devastating effects of the Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD) in Uganda.

2.2. Cassava research

In the early 2000s, the National Cassava Research Programme of NARO instituted cassava innovation platform (CIP) in most of the CBSD and CMD-affected regions of Uganda with the aim of bringing together farmers, researchers and other relevant stakeholders and finding sustainable solutions to the cassava disease problems. Under this arrangement, improved cassava varieties that met specific farmer needs were developed through Participatory Plant Breeding (PPB) and Participatory Variety Selection (PVS). Drawing on these experiences, the Eastern Africa Agricultural Productivity Project (EAAPP) launched a cassava research initiative under the framework of the Cassava Regional Center of Excellence (CRCoE) in 2010. The initiative brought together national and regional actors and created an opportunity for them to interact in the context of the AIS concepts, allowing them to develop improved cassava varieties that were highly accepted by farmers (Wellard et al., 2015). One unique element of this AIS initiative is the free exchange of cassava germplasm across national borders amongst the four countries (Ethiopia, Kenya, Tanzania and Uganda) that implemented the regional EAAPP project. In Uganda, the AIS initiative was implemented in more than 12 districts of which four (Lira, Apac, Kiryandongo, and Masindi) are selected for this study.

2.3. Cassava seed supply

In Uganda, the private sector continues to focus on non-vegetatively propagated crops, leaving the smallholder cassava farmers with no option but to depend on informal cassava seed supply system that lack inspections and certification (Rubyogo et al., 2007). The lack of interest on the part of the private sector in the cassava seed markets led to the establishment of a community-based commercialized system called the Cassava Seed Entrepreneurship (CSE) AIS initiative. The CSE initiative is a research for development intervention of NARO-NaCRRI that brings together various players in the cassava seed value chain and uses AIS concepts to establish a functional commercialized cassava seed delivery system in Uganda. The major actors include researchers, farmers, input suppliers (seed multipliers), inspectors and regulators (seed certifiers), NGOs. In particular, the CSE comprises cassava researchers from NaCRRI who, together with cassava farmers, develop popular cassava varieties through the PPB and PPS; NaCRRI agronomists that train CSEs in cassava agronomic practices; cassava farmers that serve as CSEs; cassava seed multipliers that operate through tissue culture (TC) mass production and farmer field seed bulking (BioCrops and NARO-ZARDIs (Zonal Agricultural Research and Development Institutes)); NGOs that provide capacity building in business and market linkage dynamics (MEDA, Afrii and CHAIN); the National Seed Certification Services (NSCS) agency of the Agriculture Ministry that provides seed inspection and certification services; and finally farmers who buy and use certified cassava seed.

The CSE initiative operates in seven districts of which three (Lira, Kiryandongo, Masindi) are covered in the study. The CSE AIS initiative builds the skills and knowledge of communities, local service providers, local and central government agricultural inspectors, individual farmers and farmer groups to engage effectively in markets. Like the Enabling Rural Innovation (ERI) initiative of CIAT in Sanginga et al. (2009) and Mapila et al. (2012), the CSE AIS initiative aims to create an entrepreneurial culture in Uganda's cassava rural communities by enabling farmers to produce and sell certified cassava seed, leading to the development of a functional commercialized cassava seed system in Uganda.

3. Model

We estimate the ESR model to assess the impact of adoption on cassava productivity and household welfare. The ESR model is comprised of a selection equation or criterion function and two linear regressions associated with the outcomes. The treatment or selection equation (1) establishes the regime of the household and two equations describing productivity and welfare outcomes for the adopters (2a) and non-adopters (2b) is defines as:

$$T_i^* = \beta X_i + \mu_i \quad (1)$$

$$Y_{1i} = \alpha_1 C_{1i} + e_{1i} \quad \text{if} \quad T_i = 1 \quad (2a)$$

$$Y_{0i} = \alpha_0 C_{0i} + e_{0i} \quad \text{if} \quad T_i = 0 \quad (2b)$$

Where T_i^* is the unobservable latent variable defining the technology adoption regime, T_i which is the observable counterpart; X_i represents the vector of covariates determining adoption; Y_i denotes the productivity or welfare outcome in regime 1 (adopters) and 0 (non-adopters); C represents the set of covariates determining productivity or welfare outcome. The error terms μ_i, e_{1i}, and e_{0i} are assumed to have a trivariate normal distribution with zero mean and a covariance matrix:

$$\begin{pmatrix} \sigma_{e1}^2 & . & \sigma_{e1u} \\ . & \sigma_{e0}^2 & \sigma_{e0u} \\ . & . & \sigma_u^2 \end{pmatrix} \quad (3)$$

If σ_{e1u} and σ_{e0u} are different from zero, the expected values of the error terms of the productivity or welfare outcomes are non-zero and equal to:

$$E[e_{1i}|T_i = 1] = \sigma_{e1u} \frac{\phi(\beta X_i)}{\Phi(\beta X_i)} = \sigma_{e1u}\lambda_{1i} \quad (4a)$$

$$E[e_{0i}|T_i = 0] = \sigma_{e0u} \frac{\phi(\beta X_i)}{1-\Phi(\beta X_i)} = \sigma_{e0u}\lambda_{0i} \quad (4b)$$

Where $\phi(.)$ and $\Phi(.)$ indicate, respectively, the standard normal density and standard normal cumulative functions. If the estimated covariates σ_{e1u}' and σ_{e0u}' turn out to be statistically significant, then the decision to adopt certified ICVs is correlated with the cassava productivity or consumption expenditure, implying that there is evidence of endogenous switching and the presence of sample selection bias (Magrini and Vigani, 2016; Loskin and Sajaia, 2004; Maddala and Nelson, 1975).

The ESR estimation follows a two step-procedure where, in the first stage, adoption is estimated using the probit model while, in the second stage, the impact of adoption on the consumption expenditure is estimated using the OLS estimation procedure with a selectivity correction. However, the model can be estimated efficiently using the full information maximum likelihood (FIML) (Lokshin and Sajaia, 2004). The FIML method simultaneously estimates the probit model of certified ICVs and the linear regression equations of productivity and consumption expenditure. The ESR model is identified by construction through non-linearity. As was the case in Heckman et al. (2001), the results of the FIML estimation are used to calculate the average treatment effect on the treated (ATT) by comparing the expected productivity and consumption expenditure outcomes for adopters against their counterfactual scenario such that:

$$E[Y_{1i}|T_i = 1] = \alpha_1 C_{1i} + \sigma_{e1u}\lambda_{1i} \quad (5a)$$

$$E[Y_{0i}|T_i = 1] = \alpha_0 C_{1i} + \sigma_{e0u}\lambda_{1i} \quad (5b)$$

$$E[Y_{1i}|T_i = 1] - E[Y_{0i}|T_i = 1] = C_{1i}(\alpha_1 - \alpha_0) + \lambda_{1i}(\sigma_{e1}^2 - \sigma_{e0}^2) \quad (6)$$

4. Data and variable description

4.1. Data and sampling

Data for the study came from a household survey conducted in Uganda in 2015. The data were collected on several biophysical, socioeconomic and institutional household characteristics using a pre-tested structured questionnaire administered by trained and experienced enumerators. The selection of the sample households involved a multi-stage sampling procedure based on a sampling framework constructed from the NaCRRI's database that consist of coded cassava growing households who participated in several previous surveys (NARO, 2011, 2014) as well as the lists of registered and active cassava farmers obtained from District Agricultural Officers (DAOs), NARO Zonal Agricultural Research & Development Institutes (ZARDIs) and local agricultural extension offices in the Eastern, Northern and Mid-Western Uganda. First, based on their importance[2] in cassava production, twelve (12) districts were purposively selected from the three major cassava growing regions (Table 1). Then, four sub-counties were randomly selected from each of the 12 districts, resulting in a total of 48 sub-counties. Finally, 12 households were selected from each of the 48 counties, resulting in a total of 612 households.

Table 1: Districts by region selected for the study

Region	Most vibrant	Least vibrant
Eastern	Serere and Ngora	Kaliro and Kamuli
Northern	Apac and Amoratar	Lira and Oyam
Mid-Western	Masindi and Kiryandongo	Kyenjonjo and Hoima

During data processing, 3 questionnaires were discarded for lack of consistency leaving us with 609 households to use for the data analysis. To mitigate the challenges of reverse causality in impact estimation, the questionnaire was designed to capture both adoption and pre-adoption data on selected variables such as wealth and assets,

[2] Importance was defined by level of cassava production, local significance of the cassava commodity and community participation intensity in cassava initiatives

access to extension and credit, group membership, etcetera. This is important for assessing impact of technology adoption using pre-adoption covariates.

4.2. Description of variables used in the study

The study has one treatment variable – adoption (measured by asking the selected households whether or not they planted certified or uncertified planting materials of ICVs or local varieties in 2015), and two outcome variables – cassava productivity, and household food consumption expenditure. Productivity was measured as root yield (Kgs/acre) while household welfare was measured as per capita household consumption expenditure. The consumption expenditure was measured by asking the selected household on food expenditure for the preceding year covering a period of 12 months consistent with the World Bank's LSMS-ISA standard module. The study has several independent variables, falling under three categories: demographic, socioeconomic and institutional. Under the demographic category, sex, age of the household head, educational level, and family size were included. Educational level is defined by a continuous variable that captures the total number of formal education years of all household members divided by the household size. Age of the household head is also a continuous variable measured in years. Household head's gender is included as a dummy variable that takes on the value of 1 if household head is female and 0 if male. The socioeconomic category includes ownership of communication means, transport means, livestock as measured by Tropical Livestock Units (TLUs[3]), total land holdings in acres, and per capita total asset value (UGX) of a household. Similarly, the institutional category includes access to extension, training and group membership. Access to extension, credit services, training on use of improved varieties, agronomy and marketing, household membership to a farmer group or association in the pre-intervention year (2010) are included and defined by dummy variables that take on the value of 1 if the household received extension services, and training in 2010, and 0 if otherwise. Finally, region is included to assess the effect of geographical location on decision to adopt certified ICVs. The regions are defined by dummy variables taking on the value of 1 if a household reside in the Mid-western or Northern regions, and 0 for

[3] TLUs are livestock numbers converted to a common unit. Conversion factors are: cattle = 0.7, sheep = 0.1, goats = 0.1, pigs = 0.2, chicken = 0.01 (Harvest Choice, 2011).

Eastern region. The Eastern region is the largest producer followed by the Northern region and the Western region (UBOS, 2015). In terms of population, the Eastern region is the most populated region followed by the Western region and the Northern region.

5.0. Results

In this section, we first present the descriptive statistics of the household characteristics and outcomes between adopters of certified ICVs and local varities, followed by results on the estimates of the average effect of adoption of certified ICVs on cassava productivity and consumption expenditure from the ESR model.

5.1. Descriptive statistiscs

Descriptive results are presented in Table 2. For example, a relatively larger proportion of farmers, who adopted certified ICVs, belonged to Agricultural Innovation Platforms (AIPs), other farmer groups and reported to have received extension services in 2015 than the farmers who planted local seed. Specifically, 55% of farmers who adopted certified ICVs were AIP members compared to 13% of those who cultivated local seed and the difference is statistically significant at 5%. In terms of social capital, the farmers who adopted certified ICVs had 31 people they could rely on in times of need, compared to 21 people reported by farmers cultivating local varieties, and the difference is statistically significant. With regard to dependence burden, the farmers who adopted certified ICVs are less burdened than those that cultivated local seed. The results also show that the adopters of certified ICVs had access to more communication channels than those who cultivated local seed. For instance, 23% of adopters of certified ICVs own television, compared to just 7.5% of farmers who cultivated local seed. In addition, 84% of adopters of certified ICVs reported to own radios, compared to 70% of farmers who cultivated local seed. The results also show that a relatively large proportion of the adopters of certified ICVs own transportation means such as motor-vehicles, and motorcycles, compared to those who cultivated local seed. For instance, 8% of adopters of certified ICVs reported that they own motor vehicles compared to 1% of farmers who cultivated local seed. Likewise, 29% of farmers who applied certified ICVs own motorcycles, compared to 13% of farmers who cultivated local seed.

Table 2: Descriptive statistics of control variables

Variable	**Certified ICVs**	**Local varieites**	**t-statistic**
HH is a member of an AIP (1=yes)	0.545 (0.500)	0.131 (0.338)	0.414***
HH head belongs to a group (1=yes)	0.879 (0.328)	0.738 (0.441)	0.141***
HH Received Extension in 2015 (1=yes)	0.333 (0.474)	0.085 (0.280)	0.248***
# of people relying upon in times of need	30.6 (35.0)	21.4 (25.4)	9.161***
# of people rely upon for free seed	4.929 (14.5)	15.6 (31.0)	-0.740
Dependence ratio	0.948 (0.688)	0.393 (0.937)	-0.445***
HH had TV (1=yes)	0.232 (0.424)	0.075 (0.264)	0.157***
HH had radio (1=yes)	0.838 (0.370)	0.695 (0.461)	0.143***
# of Education school years of HH head	9.8 (4.6)	7.4 (4.3)	2.364***
Age of HH head	48.4 (13.9)	44.3 (13.7)	4.163***
Family size	7.0 (2.6)	6.9 (2.6)	0.130
HH Total land operated (Acres)	22.5 (77.0)	7.3 (23.2)	15.195***
HH rented in land (1=yes)	0.121 (0.328)	0.062 (0.242)	0.059**
Tropical Livestock Units (TLUs) 2015	4.566 (6.299)	1.995 (2.384)	2.571***
PCT AssetValue2015 (‘000,000 UGX)	14.7 (38.6)	5.23 (11.1)	9.47***
n	*99*	*305*	

*Figures in parenthesis are standard deviations; * p<0.1 is significance at 10%; ** p<0.05 is significance at 5%; and *** p<0.01 is significance at 1%*[4]

In terms of demographic household characteristics, the heads of households that adopted certified ICVs have higher schooling years (10 years) than those who cultivated local seed (7 years). In addition, the household heads of those that adopted certified ICVs are older than those who used local seed. In terms of access to land, the households that adopted certified ICVs have significantly more operated land (22 acres or 8.91 ha) than those who cultivated local seed (7 acres or 2.83 ha). Also, the results indicate that the majority of adopters of certified ICVs planted them on land largely acquired through renting as compared to those who cultivated local seed. The households which adopted certified ICVs are wealthier than those that cultivated local seed in terms of Tropical Livestock Units (TLUs) and per capita asset value. The

[4] Variable abbreviations in full: PCHH= Per capita Household; TLUs= Tropical Livestock Units; PCT= Per capita total; HH= Household

descriptive results suggest that adopters and non-adopters are systematically different. In the face of such systematic differences, it will be difficult to causally attribute any observed difference in outcome variables to adoption.

Table 3 presents the descriptive results on the outcome variables of the farmers who adopted certified ICVs, compared to those who planted local seed. The study tests for the difference in the characteristics between the two groups. The results show that farmers who adopted ICVs have significantly higher yield than those who cultivated local seed. In addition, the welfare measures are more favorable to the farmers who adopted certified ICVs than those who planted local seed. For example, the per capita household consumption expenditure[5] of farmers who adopted certified ICVs was UGX 1,451,000, compared to UGX 977,000 for the famers who cultivated local seed and the difference is significant at 1%. The household per capita cassava income is also higher for the households that adopted ICVs than those that planted local seed.

Table 3: Summary statistics of outcome variables

Variable	Certified ICVs	Local	t-test
Parcel root yield (Kgs/Acre)	3154 (2687)	2518 (1935)	635
PCHH Consumption Exp '000,000 (UGX)	1.451 (1.952)	0.977 (0.611)	0.473***
PC HH Food Expenditure ('000,000 UGX)	0.801 (0.483)	0.675 (0.399)	0.126***
PCHH CassIncome'000 ('000,000 UGX)	1.927 (5.261)	0.383 (2.389)	1.544***
n	97	305	

The difference between adopters and non-adopters in outcomes such as yield could well be due to the difference in the observed characteristics such as wealth, education, access to credit and extension services. The next section presents the results of a multivariate analysis based on the ESR model, controlling for all the differences in measured household characteristics and unmeasured heterogeneity.

[5]Quantities measured and reported in nonstandard units were converted into standard units using conversion factors reported in the survey as well as the conversion factors used in the production and consumption modules of the Living Standards Measurement Study–Integrated Surveys on Agriculture (LSMS-ISA). Since literature reports a valid concern that households might systematically undervalue consumption from own production, care was taken to probe for correct valuations.

5.2. Model results

Table 4 reports the ESR model results on the cassava productivity and welfare outcomes (consumption expenditure and cassva cash income) under observed (to adopt) and counterfactual conditions (not to adopt). The average treatment effect on the treated (ATT) provides the estimate of the effect of use of certified planting materials of ICVs on the adopters. The ATTs are interpreted as the mean differences in productivity and household welfare under observed and counterfactual conditions. Overall, the results indicate that adoption of ICVs would increase yield and household welfare. Specifically, the ATT on productivity indicate that farmers who adopted ICVs harvested 4,231 Kgs/acre more than they would have harvested had they used local seed. This is in agreement with Kassie et al. (2012), Shiferaw et al. (2014), Kassie et al. (2015), and Magrini and Vigani (2016) who found that ICVs can improve productivity. In conformity with the Uganda national statistics, the results indicate that farmers who adopted certified ICVs harvested 18.6 t/ha which lies between the national figure of 7-12 t/ha for on farm root yield and 25-35 t/ha for on-research station root yield (NARO, 2014; UBOS, 2016; FAO, 2016). While the on-farm improved cassava root yield figures are 8-15 tones/ha, our results revealed 18.6 t/ha indicating an improvement of 7.1 t/ha which can be attributed to seed inspection and certification. Similarly, while the yield of ICVs under on-station research conditions are 25-35 t/ha, our results revealed 18.6 t/ha generating a yield gap of 6.4 tones/ha, which could be attributed to difference in agronomic management.

With regard to welfare, adopters of certified ICVs had 32.3% more household consumption expenditure than they would have if they had used local seed and the difference is statistically significant at 1% level. In addition, farmers who adopted cerified ICVs earned 87% more cash income from cassava than they would have earned had they planted local seed and the difference is statistically significant at 1% level. In agreement with Bezu et al. (2014), Shiferaw et al. (2014), Kassie et al. (2015), and Khonje et al. (2015), our results suggest that adoption of ICVs, through increasing productivity, enhances welfare.

Table 4: Impact of certified ICVs on cassava productivity and welfare using ESR model

Outcome variable	Adoption decision		
	To adopt	***Not to adopt***	**ATT**
Cassava Root Yield (Kgs/acre)	7542.19	3310.74	4231.45***
Cons. Expenditure ('000 UGX)	7.425	7.101	0.323***
Cassava Income ('000 UGX)	6.127	5.257	0.870***

5. Conclusion and implications

The study rejected the the hypothesis of no productivity and welfare difference between farmers who adopt certified ICVs and those farmers using local cassava seed. It demonstrated that use of ICVs leads to increased productivity and improved welfare outcomes. The results suggest that the efforts made by the Ministry of Agriculture at the national level for the diffusion of cassava technologies, such as intensification of seed inspection and certification services and promotion of Cassava Seed Entrepreneurs go in the right direction with respect to the goal of increasing cassava productivity and household welfare.

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