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THE SUSTAINABILITY OF FARMER-LED MULTIPLICATION AND DISSEMINATION OF HIGH-YIELD AND DISEASE RESISTANT GROUNDNUT VARIETIES

by

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Executive Summary

The major objective of this study is to evaluate the adoption of groundnut varieties that are high yielding, drought tolerant, and groundnut rosette disease (GRD) resistant in eastern Uganda. In particular, this study examines differences in adoption and farm-level productivity associated with participation in the project entitled "Farmer-Led Multiplication of Rosette Resistant Groundnut Varieties for Eastern Uganda" (FGSM), which was carried out during the early 2000s following the prior diagnostic work under the LIFE project (Tino, Laker-Ojok, and Namisi 2004). We are particularly interested in the sustainability of the project outcomes 10-years after the end of the original intervention. The impact of the Multiplication Project is examined with respect to increased productivity (higher expected yields) and risk-reduction (improved disease resistance and drought tolerance). We also examine current levels of aflatoxin awareness, prevalence, and the use of mitigation practices in the study region.

We find that participating farmers allocated 21% more of their available land to improved groundnut varieties. The results also show that, for improved varieties, beneficiaries produce 32% higher yields than the non-participating neighbor controls, and 55% higher yields relative to non-neighbor controls. This implies that the project led to a sustained significant increase in profitability for participating farmers.

In addition, we observe significant spillover effects from the project, which is clearly revealed by the yield difference between non-participating neighboring control households and non-neighbor control households. These results imply that project beneficiaries transferred some benefits to the neighbor control group over the course of the 10-year period following the project. This is an important result suggesting that farmer-led programs offer significant advantages to developing communities and may provide a cost-effective means of information and technology dissemination.

Key words – groundnut, agricultural productivity, technology adoption, extension, impact evaluation, instrumental variables, propensity score matching, Uganda.

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I. Background & Motivation

A prominent feature of rural households (HHs) in developing countries is the reliance on subsistence-level farming as a primary source of food and fiber (World Bank 2007). This feature reveals the inherent risk faced by poor communities as these populations cope with nutritional and financial challenges stemming from crop failures, famine, and a lack of access to well developed markets. These risks are expected to be exacerbated by global climate change; consequently, food insecurity in many parts of the world is likely to worsen (Field and Van Aalst 2014). Research that evaluates the causes and degree of food insecurity suggests that climatic related threats are particularly significant in sub-Saharan Africa (Smith, El Obeid, and Jensen 2000; Smith, Alderman, and Aduayom 2006). In response to these concerns, the greatest food security gains need to come from productivity growth and increased off-farm employment (Barrett 2010; World Bank 2007). Thus, it is critical for researchers to continue to study potential mechanisms that can improve agricultural productivity, specifically for highly nutritious crops.

The research presented herein focuses on the role of agricultural technology adoption on increasing HH productivity growth. In particular, it looks at groundnut farming in eastern Uganda and the response by farmers to a program that sought to provide access to high-yielding disease resistant groundnut varieties (HYRVs). Groundnuts provide significant nutritional benefits and are an important staple in the diet of eastern Uganda. Moreover, groundnuts are a nitrogen fixing legume and are used in crop rotations as an effective means of improving soil quality (Okello, Biruma, and Deom 2010; Okello et al. 2014; Okello et al. 2015). Yet, plant diseases historically have been a major constraint to production for farmers in the region growing groundnuts (Naidu et al. 1999).

Bonabana-Wabbi et al. (2006) provide evidence that yield losses from pests and disease exceeded losses from poor soil, drought, and inferior planting material for groundnut producers in eastern Uganda. Major declines in domestic groundnut production during the 1970s have given way to steady growth in more recent years (Okello, Biruma, and Deom 2013). From 2005 to 2012, domestic groundnut production increased by 31% to 295,000 metric tons with 421,000 hectares harvested, surpassing the previous production highs of the early 1970s (Tanellari et al. 2014). These substantial increases in domestic production are largely attributed to the uptake of improved production practices and HYRVs (Shiferaw et al. 2010). Kassie et al. (2011) suggest that groundnut producers in Uganda have benefited significantly from improved varieties exhibiting average yield gains of 35% and average per unit cost reductions around 40%. Improved seed varieties are thus a cost-effective approach to improving yields and returns to farmers.

The National Semi-Arid Resources Research Institute (NaSARRI) in Serere, which is part of Uganda's National Agricultural Research Organization (NARO), has released a number of new groundnut varieties including Igola and Serenut 1-6 (Okello et al. 2016; Wambi et al. 2015).

These varieties offer a less risky alternative to groundnut producers when compared to the land race varieties that are widely cultivated. At the time of the project, in 2002, it is estimated that 90% of all crops in Uganda came from home-saved seeds, i.e., land race varieties, and by 2014 10-15% of Ugandan farmers planted improved seeds (Joughin 2014a; Mwebaze 2002). Researchers have identified improved seeds through breeding programs and selection of introduced and locally adapted varieties that are disease and drought resistant (Shiferaw et al. 2010; Okello et al. 2015). At the same time, experts have cited the relatively high cost of purchased seeds to poor farmers as well as the limited profitability associated with seed multiplication and production as the two major hurdles to seed adoption (Joughin 2014a). Furthermore, concerns have been raised over the increased prevalence of counterfeit or fake seeds in the market, which is both exploitive and likely to be a further disincentive to adoption by small farmers (Joughin 2014b). Yet, the associated productivity gains from improved seeds contribute to poverty reduction and food security among adopters. Correspondingly, a significant body of literature demonstrates the importance of technology adoption to development, with particular attention given to the uptake of high yielding seeds in India (Foster and Rosenzweig 2010; Foster and Rosenzweig 1995). Notable studies in Africa by Conley and Udry (2001; 2010) highlight the role of networks in the dissemination of agricultural technologies. More recently, work in Uganda by Shiferaw et al. (2010), Kassie et al. (2011), Thuo et al. (2013; 2014) focuses directly on groundnut producers.

An earlier survey of farmers located in eastern Uganda conducted during the LIFE project that begun in 1999 and was implemented by Appropriate Technology Uganda (ATU), revealed that groundnuts were not being grown by poor farmers because of the high risk associated with production, even though groundnuts were highly profitable compared to other regional crops (Tino, Laker-Ojok, and Namisi 2004). One important source of risk stems from the high seeding rate in groundnuts, relative to production, and another is the threat of crop failure from various plant diseases (Okello et al. 2015). Although diseases can be controlled using chemicals, availability is limited, especially to poor farmers, and diseases are observed to become more resistant to these methods over time, requiring greater inputs at an even higher cost (Mugisa et al. 2015). The use of disease resistant seed varieties offers a cost-effective and sustainable alternative to combating disease related crop failure and is thereby likely to provide significant benefit to poor farmers (Moyo et al. 2007). The diagnostic results from the LIFE Project provided the basis and justification for the follow up project "Farmer-Led Multiplication of Rosette Resistant Groundnut Varieties for Eastern Uganda" (FGSM) carried out from 2001 to 2004 (Tino, Laker-Ojok, and Namisi 2004). The goal of that project was to increase the availability of HYRVs and in turn generate significant benefits to groundnut farmers.

The research presented provides a novel contribution to the existing literature on technology adoption by focusing on the sustainability and lasting impact of an intervention implemented 10-years before the most recent data collection event. Specifically, our primary research question is: did the FGSM project result in increased dissemination and adoption of HYRVs by participating

HHs over the last 10 years? The overall findings illustrate the importance and effectiveness of continued farmer-led extension efforts in sub-Saharan Africa, particularly in Uganda, with respect to the adoption of new and improved technologies.

Another component of our analysis is directed at aflatoxin, which is an important consideration in light of its apparent prevalence in Africa and harmful effects on humans and animals (Okello, Biruma, and Deom 2010; Wild, Miller, and Groopman 2015). A major concern with groundnut production is mold contamination, which can result in the accumulation of toxic compounds known as mycotoxins in the pods (Okello et al. 2010). Aflatoxin, a particularly problematic mycotoxin produced by the mold *Aspergillus flavus,* negatively impacts the health of humans and livestock when consumed. It is a carcinogen and is known to cause birth defects when eaten regularly during pregnancy (Turner et al. 2005). Moreover, aflatoxin has been linked to stunting in children, which in turn is linked with cognitive deficiencies (Khlangwiset, Shephard, and Wu 2011).

Given the risks of aflatoxin to rural HHs and communities, there is growing need to generate and disseminate information, particularly to poor farm households, to increase the capacity of effectively diminishing contamination in groundnuts throughout Africa (Otsuki, Wilson, and Sewadeh 2001; Turner et al. 2005; Okello et al. 2010; Florkowski and Kolavalli 2013; Masters et al. 2015). Many of these efforts focus on post-harvest handling and processing, though attention has also been given to on-farm pre-harvest practices in more recent years, such as weeding, fertilization, and the timing of planting and harvest (Florkowski and Kolavalli 2013; Okello et al. 2010). Therefore, our 2014 survey included a series of questions to assess general HH-level aflatoxin awareness and mitigation practices. The information collected is mostly diagnostic in nature, since aflatoxin was not included in the scope of the original FGSM Project. Using data from the 2014 survey we examine the current state of awareness, perceived prevalence, and mitigation practices for aflatoxin across the districts and groups included in the study.

The remainder of this report is structured as follows: the second section presents the theoretical framework for our research; the third section describes the dissemination program design, data, and empirical strategy for our estimations; the fourth section provides the results and a brief discussion; and the final section presents conclusions.

II. Theoretical Framework & Methodology

An effective means of mitigating the risks associated with HH crop production is through the use of improved technologies in order to promote higher productivity (Bravo-Ureta et al. 2007; Bravo-Ureta et al. 2012; Villano et al. 2015; González-Flores et al. 2014). These technologies may include the adoption of new or improved inputs, such as machinery, chemical inputs, irrigation, and high-yielding, disease and drought resistant seed varieties. Yet, the availability of new technologies does not directly translate into adoption; education and outreach are necessary components to facilitate this process (Conley and Udry 2001; Foster and Rosenzweig 1995). Economic feasibility is also critical to adoption, i.e. the expected returns associated with adoption must be higher than those obtained from the current technology (Kassie, Shiferaw, and Muricho 2011). For these reasons, inter-governmental and non-governmental organizations facilitate adoption by making new technologies readily available and lowering the overall cost of adoption for poor HHs (Cromwell et al. 1993; Langyintuo et al. 2008). Further consideration is given to targeting specific crops expected to have a significant regional impact on increasing food security among the rural poor, which is necessitated by concerns over population growth and pressures associated with global climate change (Lobell et al. 2008; Godfray et al. 2010).

The theoretical framework for technology adoption is based on the notion of utility maximization. Thus, HH i adopts if the expected utility from adoption (U_{iA}) is higher than non-adoption (U_{i0}); stated differently, U_{iA} - $U_{i0} > 0$ (Ali and Abdulai 2010; Becerril and Abdulai 2010; Kassie, Shiferaw, and Muricho 2011). Since utility itself is not observable, empirical models typically rely on a binary or fractional dependent variable (set between 0 and 1), where 0 represents non-adoption, values between 0 and 1 represent partial adoption, and 1 represents full adoption (Asfaw et al. 2012; Kassie, Shiferaw, and Muricho 2011). The classic version of the model relies on a purely binary dependent variable, where individuals are considered either adopters or non-adopters (Comin and Mestieri 2010). The appropriate model is technology dependent, because adoption may be: (1) an all-in condition; (2) assume a cutoff level for adoption (e.g., 50% or more of the area is devoted to the new technology); or (3) measured as a continuous fractional variable. Ultimately, the question is not simply whether or not a new technology is adopted, but also how much so, since farmers balance their preference for specific characteristics and risk attitude when making production decisions and allocating their limited resources. Further constraints to the adoption decision for poor HHs include limited access to credit and market demand for specific variety characteristics (Foster and Rosenzweig 2010).

Methodologically, the identification of causal effects associated with the FGSM project is the primary task of this research, namely: did the dissemination efforts lead to greater uptake of HYRVs? Given the variables included in the 2004 survey, analysis using the panel dataset over the 10-year period from 2004 to 2014 is restricted to a binary measure, where HHs that planted *any* HYRVs are considered adopters ($y_i = 1$) and HHs that did not plant HYRVs are non-adopters ($y_i = 0$). The more detailed micro-level data collected in 2014 allows for additional insight into the nature of adoption at the HH level. In this case, the indicator of adoption is specified as the proportion of area planted in HYRVs out of the total area planted in groundnuts; therefore adoption takes a fractional value from 0 to 1, as opposed to *only* 0 or 1 in the former case. This fractional measure requires a more intense recall from growers so the data should be collected close to the end of the production period to insure reliability.

Controlling for various exogenous factors, we assume that the association between adoption and program participation provides a good estimate of the impact of training. First, the effect of the program is evaluated by estimating equation (1) via ordinary least squares (OLS). The model can be written as:

$$y_i = \alpha + \gamma p_i + \beta x_i + \mu_i \qquad (1)$$

where y_i is the indicator for adoption measured as the proportion of groundnut area planted in HYRVs; α is the intercept term; γ is the coefficient that measures impact where $p_i = 1$ for beneficiary HHs and $p_i = 0$ for non-participants; β is a vector of parameters for the covariates (x), which includes information about the household head (age, sex, marital status, and education), the sex of the respondent, location (sub-district), family size, and total HH acres cultivated; and μ is the error term (Greene 2011). Note that given the dichotomous nature of the dependent variable in equation (1), OLS estimation corresponds to the Linear Probability Model (LPM) (Papke and Wooldridge 1996).

In order to avoid biases, the ideal would be to observe a group at a given point in time in both the treated and untreated states. Clearly this is not possible; thus, it is necessary to create a counterfactual in order to be able to attribute any changes on the indicator of interest to the intervention (Gertler et al. 2011). Randomization is the primary means to generate a robust counterfactual where, in principle, the researcher simply allocates individuals from the study population into treated and control groups. However, if randomization is not incorporated into the study then other methods must be used to construct a suitable counterfactual. One such method is PSM, which is used to generate a control group that is as similar to the treated group as possible in terms of observables (Caliendo and Kopeinig 2008; Dehejia and Wahba 2002; Ravallion 2007). The average treatment effect (ATE) is then calculated based on the mean differences between the two matched groups. The ATE can be expressed as:

$$ATE = E[{y_i}^T - {y_i}^C] \qquad (2)$$

where ${y_i}^T$ is the value of the outcome indicator for the treated HHs and ${y_i}^C$ is the value for the control HHs (Winters, Salazar, and Maffioli 2010). A Probit model is used here to generate estimates of the probability of being treated, referred to as a propensity score, given a vector of observable characteristics (Greene 2011). Based on the available data the following set of variables are included in the propensity score estimation: HHH age, sex, marital status, education, family size and total acres cultivated. We then use the nearest neighbor criterion without replacement to match beneficiaries with non-beneficiary HHs and estimate the ATE (Caliendo and Kopeinig 2008; Dehejia and Wahba 2002; Leuven, Sianesi, et al. 2015). Next we consider the potential endogeneity that would arise if participation in the project (p_i) is correlated with the error term μ_i in equation (1), and utilize instrumental variable regression (IV) to address this issue (Cavatassi et al. 2011; Kassie, Shiferaw, and Muricho 2011).

Another important characteristic of an IV is that it can mitigate biases from unobservables when only cross sectional data is available (Dehejia and Wahba, 2002; Khandker et al., 2009). To evaluate the impact attributable to an intervention with an IV approach, a two-step estimation process is implemented (2SLS) (Angrist, Imbens, and Rubin 1996; J. Angrist and Krueger 2001; Stock and Trebbi 2003). Estimation with IV requires a suitable instrument (z_i) that must satisfy two important conditions: 1) it must be correlated with the regressor (p_i); and 2) it must be independent of the error term (μ_i) and uncorrelated with the dependent variable (y_i) (Duflo 2001). A particular instrument that has been applied in this context is the intent to treat (ITT), which is adopted from the experimental medical literature (Duflo, Glennerster, and Kremer 2008). Thus $z_i = 1$ for eligible members of the population, regardless of program participation (p_i), and $z_i = 0$ for non-eligible ones. In the first step, p_i is predicted ($\hat{p}_i$) as a function of ITT (z_i) as shown in equation (3), where $z_i = 1$ for all HHs in program villages (Cavatassi et al. 2011). In the second step, OLS is done with the predicted value ($\hat{p}_i$) generated in the first step, as shone in equation (4). The same set of covariates (x) included in the OLS model (1) are included in both (3) and (4). Thus, the estimating equations are:

$$\hat{p}_i = \vartheta + \delta z_i + \varphi x_i + \epsilon_i \tag{3}$$

$$y_i = \alpha + \gamma \hat{p}_i + \beta x_i + \mu_i \tag{4}$$

Given the 10-year gap between the program completion and the follow up survey, bias from external contamination is another source of concern. External contamination comes from other programs and activities that are likely to produce similar outcomes to the project under evaluation (Baker 2000; Gertler et al. 2011). In this case, we assume local authorities and NGOs are responsible for such activities. We therefore examine the presence of sources of external contamination based on the response to questions in the 2014 survey concerning the involvement of HHs in any other programs or farm groups over the last decade. Analysis of these data revealed that contamination is not an issue in this sample.

III. Project Scope & Data

In an effort to promote adoption of improved groundnut varieties, the FGSM project promoted farmer-led multiplication of high yielding, drought tolerant, and groundnut rosette disease resistant material by poor households under the supervision of local authorities. ATU facilitated the access to new varieties through the following set of outputs:

(i) Extension staff, local authorities, and farmers trained in groundnut production and storage.
(ii) Foundation seed for new groundnut rosette disease resistant varieties obtained and multiplied by farmer group members.
(iii) Farmers that multiply seeds return double the amount of planting materials received, for redistribution and further multiplication.

The process of collection, redistribution, and monitoring of multiplied seed is effectively handed over to local leaders for management (Tino, Laker-Ojok, and Namisi 2004). Thus, the project was designed to be an efficient and practical means for the dissemination of HYRV seeds. Lessons from previous projects indicate that farmer-led seed multiplication can be an effective means of promoting access to and utilization of HYRVs and best practices, resulting in increased productivity among resource poor HHs. The project expected to achieve the following targets, each of which are assessed and documented in the December 2004 ATU Final Technical Report:

(i) Production of groundnuts by 9000 poor participating farmers.
(ii) 16 Extension staff, 300 community leaders (160 contact farmers and 140 local leaders), and 2000 households trained in groundnut seed production, storage and multiplication.
(iii) Sufficient foundation seed to plant 400 acres (161.9 Ha) of new varieties obtained and multiplied by the end of project (EOP).
(iv) Redistribution and further multiplication of sufficient improved groundnut varieties to plant at least 2500 Ha by EOP.

The FGSM project was conducted from 2001 to 2004. The end goal of the project was to increase the adoption of HYRVs by making seeds readily available to farmers. In order to evaluate project outcomes, a survey was completed close to the end of the project in 2004, and an additional survey of the same HHs was completed in 2014 to assess the lasting impacts of the intervention. The 2014 survey contained additional outcome indicators to assess the nature of HYRV adoption in greater detail. A major advantage of the data (2004 and 2014) is that it includes information for both participants (*Beneficiaries*) and their non-participant counterparts (*Controls*). We employ a cross-sectional approach to estimation in order to exploit the greater detail of the 2014 data. Panel data (combining 2004 and 2014 surveys) is also used to assess attrition and demographic consistency, which is important given the long time period between the original data collection and analysis (Schultz and Strauss 2008).

Uganda is divided into 112 districts (Figure 1-A) and each district is subdivided into 1 to 5 counties for a total of 181 counties, which are then split into a total of 1,382 sub-counties. Sub-counties are divided into parishes that are made up of a group of villages with many HHs (Rwabwogo 2007). For the purpose of the seed dissemination project, participating HHs were grouped into local farmer associations within selected parishes. Non-participating HHs were therefore not members of the farmer associations included in the dissemination project, but may be neighbors of participating HHs, i.e. residents of the same village, or of a village that did not include any participating HHs.

At the outset of the FGSM project in the early 2000s, randomization was used to determine project locations. First, half of the sub-counties in a given district were randomly selected to participate in the project. A single parish was then chosen at random within each of the selected sub-counties. Then, three farmer associations were selected from each parish and finally 10 members from each participating farmer association were randomly selected as respondents. Non-participating HHs were selected at random from project and non-project parishes. The following explicitly describes the composition of the sample:

Beneficiaries (BEN): The final sample of program beneficiaries consists of 8 sub-counties, 8 parishes, and 24 farmer associations, for a total of 240 HHs (10 members from each farmer association).

Control: A two-part control group was also sampled to provide a suitable counterfactual. The first part of the total control group was made up of five HHs neighboring beneficiaries from each of the beneficiary farmer associations. The neighbors were randomly selected, so that 15 were sampled in each sub-county for a total of 120 non-beneficiary neighbors (C_IN). The second part of the control is made up of non-participating parishes in randomly selected sub-counties. Then, a total of 15 HHs were randomly picked from each parish. Thus, a total of 120 non-neighboring non-beneficiary respondents were surveyed as the second part of the control group (C_OUT). The total control group is composed of 240 HHs.

Survey Implementation. The first survey for which we have data was conducted in late 2004 at the end of the FGSM Project. A follow-up survey was conducted in early 2014 for all 240 treatment and 240 control HHs. The 2014 survey was done by ATU and consisted of a questionnaire that recorded HH demographic and agricultural production data. The type of variables contained in the 2004 dataset and adjustments introduced in the 2014 survey are as follows:

(i) Household: demographic and socioeconomic characteristics;

(ii) Agricultural Production: total acres planted, crop and groundnut varieties grown, farmer association membership, seed multiplication participation, farming experience (years), and marketing. In addition, the 2014 survey includes: acreage and quantity of seed planted by groundnut variety, recall questions for total groundnut area in 2004, and input use (labor, fertilizer, and supplies).

The complete dataset collected in 2014 along with a full descriptive report was provided by ATU. The report describes the scope of the work done, the process by which the survey instrument was finalized, the training of the survey team and enumerators, and field-testing; as well as, general protocols, comments, and information on attrition. Original respondents were available in most cases and a limited number of replacement respondents or HHs are included in the 2014 survey. Reasons for replacement included: illness, death, relocation, imprisonment, and schooling. Overall only 12 (2.5%) of the 480 HHs in the full sample differed between 2004 and 2014. Given the 10-year period spanning between the two surveys, attrition is very limited and, based on observations from the survey team, it is unlikely that this attrition stems from systematic sources.

IV. Results & Discussion

This section provides the key results from the analysis of HYRV adoption 10 years after the completion of the seed dissemination project. The primary focus is on the difference in adoption levels of HYRVs between those who received program benefits and their counterparts who did not. We begin by examining the perception of changes in HH standard of living from 2004 to 2014 across groups. This is followed by a description of selected summary statistics for the overall population and differences across groups, which are tabulated in Appendix A (references to these tables are given in the format Table A-#). Next, we describe groundnut production practices and trends in the study region. This includes information on the varieties that are grown and regional preferences associated with them. Turning to the adoption of HYRVs, the primary focus of our analysis, we examine first the availability of and access to seeds. Statistical models are then used to estimate the differences in HYRV adoption across groups while controlling for the various factors outlined in previous sections. This is the major component of our analysis and particular attention and in-depth discussion is provided for the associated results. Productivity, production costs, and profitability are addressed in the subsection that follows. The last component of the results is an examination of aflatoxin awareness, prevalence, and mitigation practices.

A. Descriptive Statistics: Standard of Living and Income Sources

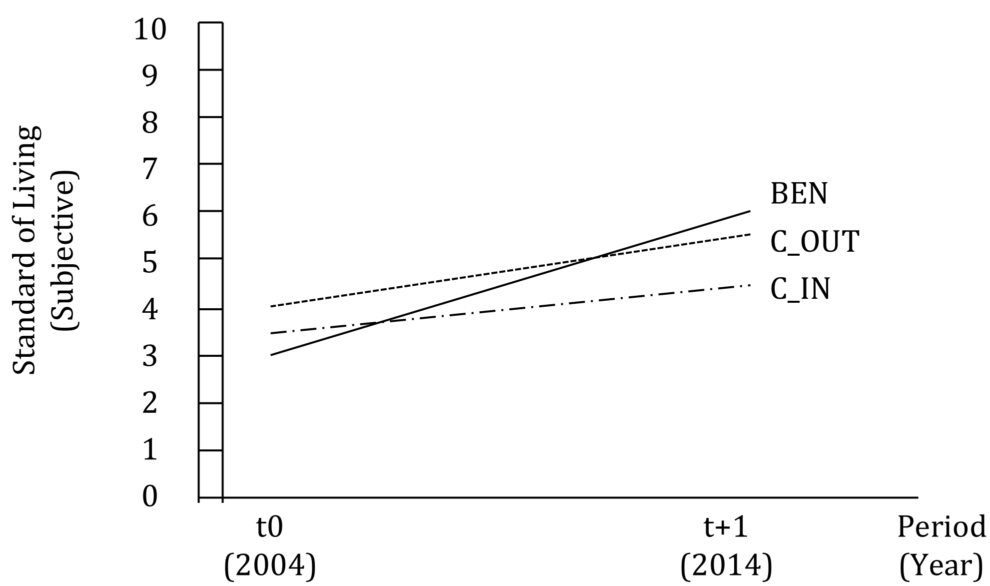

Figure 1. Changes in Mean Level of HH Standard of Living by Group (2004 -2014)

In the 2014 survey, HH respondents were asked to rank their standard of living in 2004 and 2014 on a 10-step ladder. On average, respondents indicated increases in standard of living over the 10-year period (Figure 1). The ladder on the left of Figure 1 represents the relative standard of living of the HH and respondents were asked to indicate in which step of the ladder their HH was in 2014 and in 2004. The BEN group indicated the greatest improvement in standard of living, whereas C_IN improved the least. The primary reason given for such improvements across all groups is increased HH income from agricultural production, whereas chronic illness and drought are cited as the main reasons for declines in standard of living over this period (Table 1).

Table 1. HH Standard of Living and Income

Change in Standard of Living: 2004-14	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
Increased	160	66.7	62	51.7	74	61.7	296	61.7
Decreased	65	27.1	44	36.7	40	33.3	149	31.0
No Change	15	6.3	14	11.7	6	5.0	35	7.3
Reason for Increase								
From ag. production	66	32.5	42	38.5	48	48.0	156	37.9
Can afford school fees	27	13.3	23	21.1	21	21.0	71	17.2
Purchase of HH assets	7	3.4	15	13.8	11	11.0	33	8.0
Improved housing	26	12.8	16	14.7	9	9.0	51	12.4
Acquired more land	21	10.3	9	8.3	6	6.0	36	8.7
More livestock	25	12.3	13	11.9	21	21.0	59	14.3
Secured employment	4	2.0	3	2.8	1	1.0	8	1.9
Reason for Decrease								
Continuous drought	18	8.9	9	8.3	4	4.0	31	7.5
Fragmented land	2	1.0	2	1.8	1	1.0	5	1.2
No funds for farming	6	3.0	5	4.6	1	1.0	12	2.9
Poor seeds/low yield	1	0.5	1	0.9	1	1.0	3	0.7
Limited land	11	5.4	1	0.9	3	3.0	15	3.6
Chronic illness	24	11.8	10	9.2	7	7.0	41	10.0
Primary HH Income Sources								
Crop production	239	99.6	1.07	232	96.7	1.06	471	98.1
Livestock	60	25.0	2.12	36	15.0	2.19	96	20.0
Salaried employee	16	6.7	1.81	18	7.5	1.67	34	7.1
Trading	54	22.5	2.00	61	25.4	1.92	115	24.0
Others	38	15.8	1.97	27	11.3	2.00	65	13.5
Change in Crop Income: 2004-13								
Increased	144	60.0	70	58.3	64	53.3	278	57.9
Decreased	80	33.3	39	32.5	40	33.3	159	33.1
Stayed the same	16	6.7	11	9.2	16	13.3	43	9.0

The primary source of income for HHs is from crop production across BEN and controls (Table 1). This coincides with the two major reasons given for changes in HH standard of living: (1) greater agricultural productivity, and (2) drought pressure. Ranking HH income sources in the study region places crop production at the top of the list followed by salaried employment, trading, and livestock production (Table 1). Apparently, HHs engage primarily in trade followed by salaried employment. The results show that the former is not as lucrative or consistent, in terms of income generation, compared to the latter. The general trend for crop income is consistent with overall HH income where almost 60% of HHs experienced increases in crop income, just over 30% experienced decreases, and about 10% reported no change between 2004 and 2014 (Table 1).

The average HH in the overall sample is composed of 8.5 members, with BEN HHs having slightly less members than the other groups. The typical HH has 2 children, 2 youth, 4 adults, and an average of 0.5 elders, i.e., one in every other home (Table A-1). The adults in the HH supply most of the labor for groundnut farming. HH labor is divided equally between male and female members, which is consistent with the findings from Tanellari et al. (2014). The sex of survey respondents is split 40-60% male-female for BEN respondents and 60-40% for the controls (Table A-2). Differences in the sex of the head of household (HHH) are similar for all groups with an overall proportion of male-to-female HHHs of 79-21%. Of the 101 female HHHs 93% of the respondents are female (Table A-3). Roughly 80% of HHHs are married across all groups, with the BEN group having a larger proportion of widowed HHHs than the other groups. Very few HHHs list themselves as single or divorced (<5% combined in all cases) (Table A-4). Education levels across groups are also similar with the majority (>50%) of HHHs having attained primary level, with 20% secondary level. The BEN group has the greatest diversity in HHH education, containing both the greatest proportion of HHHs with no formal schooling and ones with a tertiary degree (Table A-5). There is significant variation in the ages of HHHs from younger than 35 years old to older than 60 years. The most common age group listed for HHHs is older than 60 years and 46-50 years old, respectively (Table A-6).

Looking to farm size (Table A-7), 70% are between 1 and 5 acres, with 6% of HHs having less than an acre of land, and just under a quarter of HHs with more than 5 acres. These patterns vary across sub-counties and survey groups. This includes Kachonga and Lyama, where a greater proportion of HH farms are sized 1-3 acres in the program villages. This is also true of Bukhalu for the C_OUT group. Overall, Butiru has the greatest proportion of farms >3 acres in size, making up over 80% of HHs in both BEN and C_OUT groups, which differs significantly from the 60% makeup of C_IN HHs in the sub-county. In the C_OUT group, the sub-counties of Nagongera, Kasodo, and Kidongole, 85% of HHs farms are >3 acres in size. For all groups and sub-counties the average total area cultivated by HHs ranges from 3.2-4.3 acres with an overall average of 3.74 acres (Table A-8). The general pattern of area cultivated follows that of farm size with 70% of farms planting between 1 and 5 acres, 6% planting less than an acre, and 24% more than 5 acres.

B. HH Consumption and Crop Production

In terms of consumption, groundnuts rank 3rd and 4th as a staple food in the regional diet illustrating the importance of this crop as a source of nutrition (Table A-9). The primary crops grown vary across regions with groundnuts ranking at the top among BEN and second among controls, with maize exhibiting the highest rank in the latter case (Table A-10). Across all producers in the sample, groundnuts are ranked fourth on average in terms of income generation. Millet, rice, and maize are respectively ranked as the top three income generating crops across the full sample (Table A-11). However, with the exception of maize, few HHs grow millet and rice regardless of the apparent returns from these high-value crops to producers.

Roughly 75% of all HHs in the region grow groundnuts and maize, which are the two main crops, followed by cassava, which is grown by nearly 70% of HHs. Groundnuts are produced by 50% to 100% of HHs across the districts. The Kumi district has the largest proportion of groundnut growers with 100% among BEN HHs and 82% for controls. Sironko, on the other hand, has the lowest proportion of groundnut farming overall, with only 51% of BEN HHs and 67% of controls, and this is likely due to unsuitable growing conditions for this crop. In fact, for half of the six districts included in the study, in terms of total HHs, maize production exceeds that of groundnuts in Mbale, Sironko, and Tororo (Table A-10). This is an important consideration in controlling for regional effects during estimation.

For the 80% of HHs in the sample that produced groundnuts between 2004 and 2013, the average proportion of area in groundnut production increased by more than 10% (Table A-12). This trend was estimated using a recall method known as proportional piling, which has become widely accepted as a best practice to obtain such estimates (Chambers 2010). Farmers were given 20 beans and told that these represent the current area in groundnut production. They were then asked to add or remove beans to indicate the area in production in 2004 in relation to current levels. The results of this exercise indicated that 2004 levels represented roughly 90% of the current area for all groups. Farmers were also asked the general question as to whether or not production had decreased, increased, or remained the same. Overall, half of the HHs indicated an increase in production, with about a third listing a decrease and the remaining citing no change in production over the 10-year period. It is also worth noting that these results do not take into account HHs that do not grow groundnuts in the period covered by the last survey. The two primary reasons cited by respondents for not growing groundnuts is the lack of funds to purchase seed and to rent land, respectively (Table A-13).

i. Groundnut Production and Variety Preferences

Moving to the discussion of HH groundnut production we observe that Female HHHs are the primary groundnut growers and that the majority of HHs make joint decisions regarding income from groundnut production. This is in contrast to the overall division of labor in groundnut growing, which is split evenly between the male and female groups. Apparently, the management of the groundnut operation is more often attributed to female HHHs rather than their male counterparts. It should also be noted that this trend is strongest among BEN HHs (89%) and much weaker in the C_IN group (56%) (Table A-14). The major challenges to growing groundnuts are consistent across the groups with drought (30%), and pests and diseases

(26%) as the two most commonly listed. Finances were again observed to be a deterrent to production, consistent with what was given as the main reason for not growing groundnuts. Farmers indicated a lack of operating capital as a major challenge (20%) as well as the significant labor requirements (16%). In response to these challenges, the foremost mitigation strategy provided is timely planting (31%), followed by spraying (14.5%), and the use of HYRVs (10.9%) (Table A-15).

The survey also assessed the use of the following best groundnut farming practices: (1) site selection, (2) land preparation, (3) timely planting, (4) HYRVs, (5) spacing, (6) weed control, (7) pest control, (8) fertilizer use, (9) timely harvest, (10) proper drying, and (11) storage. Adoption for each practice was characterized as full, partial, or non-adoption. With the exception of (4) use of HYRVs and (5) spacing, implementation is consistent across groups. Eight out of the 11 practices are largely adopted (sample full adoption >80%), which include (1)-(4), (6) and (9)-(11) (Table A-16). Of the HHs surveyed roughly half of them did not adopt pest control measures and almost 90% listed no fertilizer usage. This result is consistent with recommended practices for HYRVs that require little to no pest management given their host plant resistance. Also, the general trait for groundnuts is they do not respond well to direct fertilization, with the exception of calcium deficient soils and residual fertilization from crop rotation is noted to have a positive impact on groundnut yields (Okello, Biruma, and Deom 2013). In addition, the use of pesticides and fertilizers is typically constrained by the limited financial resources available to smallholder farmers. Spacing is an important consideration in groundnut farming and significant differences are observed for the BEN group vs. controls. 81% of the BEN group adopt recommended spacing, compared to only 38% of control HHs, a difference of 43% (Table A-16).

With respect to training in groundnut production and seed multiplication, limited training was provided in the region after 2005 (Table A-17). Before 2005 training was provided almost exclusively to BEN, with the exception of the Tororo region where greater numbers of controls received training, which may be explained by the location of the region on the border of Kenya and the associated access to larger markets and opportunities for trade and information exchange. The lack of training after 2005 is an important feature of the results, indicating very limited intervention in the region over the last 10 years. On one hand, the project exit strategy allows for a clean evaluation of program effects 10-years later but, on the other, stakeholders and researchers have cited this feature of the project as being inconsistent with project aims. Yet we infer that our results are attributable to the dissemination project because the project is the primary source of regional training over the last 15 years or more, and no additional training was provided following 2005 (Table A-17).

Groundnut varieties planted are categorized as land race or HYRVs. The land race category includes the following varieties: Red Beauty, Igola 1 (reclassified as a land race variety in recent years), Erudurudu red, Etesot, Magwere, and Kitambi (Table 2). The 5 HYRVs grown by HHs are the ones released by NaSAARI, aptly named Serenut followed by an identification number,

Table 2. Varieties of Groundnuts Grown and Source of Seed in 2013 (Season A)

	BEN		C_IN		C_OUT		Total	
Varieties Grown	Count	%	Count	%	Count	%	Count	%
Land Race	**105**	**57.1**	**44**	**53.7**	**66**	**69.5**	**215**	**59.6**
Red beauty	62	33.7	31	37.8	32	33.7	125	34.6
Igola 1	2	1.1	1	1.2	3	3.2	6	1.7
Erudurudu red	33	17.9	11	13.4	27	28.4	71	19.7
Etesot	22	12.0	3	3.7	7	7.4	32	8.9
Magwere	1	0.5	1	1.2	2	2.1	4	1.1
Kitambi	0	0.0	0	0.0	1	1.1	1	0.3
HYRV	**128**	**69.6**	**55**	**67.1**	**49**	**51.6**	**232**	**64.3**
Serenut 1R	1	0.5	0	0.0	0	0.0	1	0.3
Serenut 2	121	65.8	51	62.2	47	49.5	219	60.7
Serenut 3R	9	4.9	4	4.9	2	2.1	15	4.2
Serenut 4T	14	7.6	2	2.4	1	1.1	17	4.7
Serenut 5R	1	0.5	0	0.0	0	0.0	1	0.3
Source of Seed								
Own home saved seed	131	48.2	44	46.3	47	43.9	222	46.8
Traditional	*48*	*36.7*	*17*	*38.6*	*27*	*57.4*	*92*	*41.4*
Improved	*83*	*63.3*	*27*	*61.4*	*20*	*42.6*	*130*	*58.6*
Open market	105	38.6	46	48.4	54	50.5	205	43.2
Traditional	*52*	*49.5*	*24*	*52.2*	*31*	*57.4*	*107*	*52.2*
Improved	*53*	*50.5*	*22*	*47.8*	*23*	*42.6*	*98*	*47.8*
Multiplication farmers	11	4.0	1	1.1	2	1.9	14	3.0
Research/Serere	5	1.8	0	0.0	0	0.0	5	1.1
NAADS	2	0.7	0	0.0	1	0.9	3	0.6
Bought from a stockiest	9	3.3	3	3.2	2	1.9	14	3.0
VECO	0	0.0	0	0.0	0	0.0	0	0.0
Seed company	1	0.4	0	0.0	0	0.0	1	0.2
Other	8	2.9	1	1.1	1	0.9	10	2.1
HYRV Availability								
No	218	90.8	104	86.6	106	88.3	428	89.1
Yes	22	9.1	16	13.3	14	11.7	52	10.8
Point of Availability								
Serere	3	13.6	1	6.3	0	0.0	4	7.7
Market	17	77.3	14	87.5	12	85.7	43	82.7
Stockist	1	4.5	0	0.0	2	14.3	3	5.8
NGO	0	0.0	0	0.0	0	0.0	0	0.0
NAADS	0	0.0	2	12.5	0	0.0	2	3.8
Others	0	0.0	0	0.0	0	0.0	0	0.0
Not applicable	1	4.5	0	0.0	0	0.0	1	1.9

Note: HYRV seed availability for surveyed HHs across groups is ~10% in all regions with the exception of Tororo where it is ~40%.

i.e. Serenut 1-5. Land race varieties were planted by 59.6% of HHs with an average of 20.3 kg planted on 0.63 acres, and HYRVs were planted by 64.3% of HHs with an average of 20.7 kg planted on 0.67 acres (Tables 2 and 3). The most widely planted land race variety is Red Beauty with an average of 18.3 kg planted on 0.56 acres by 34.6% of HHs. Another popular land race variety is Erudurudu red, which is planted by 19.7% of HHs. The most widely planted HYRV variety is Serenut 2 with 60.7% of HHs planting on average 20.7 kg of seed on 0.68 acres. All other varieties are grown by less than 5% of HHs in the sample with the exception of Etesot, which is grown by 8.9% of HHs.

Table 3. Quantity and Area of Groundnuts Planted by Variety in 2013 (Season A)

	BEN		C_IN		C_OUT		Total	
Mean Quantity Planted (kg)	Count	Mean	Count	Mean	Count	Mean	Count	Mean
Land Race	**105**	**19.5**	**44**	**21.0**	**66**	**21.0**	**215**	**20.3**
Red beauty	62	17.3	31	20.2	32	18.4	125	18.3
Igola 1	2	9.3	1	10.0	3	23.7	6	16.6
Erudurudu red	33	19.3	11	22.9	27	21.4	71	20.7
Etesot	22	15.1	3	10.5	7	18.1	32	15.3
Magwere	1	5.0	1	5.0	2	7.2	4	6.1
Kitambi	0	0	0	0	1	10.0	1	10.0
HYRV	**128**	**22.1**	**55**	**17.2**	**49**	**21.1**	**232**	**20.7**
Serenut 1R	1	3.0	0	0.0	0	0.0	1	3.0
Serenut 2	121	22.3	51	16.9	47	20.8	219	20.7
Serenut 3R	9	6.0	4	17.0	2	10.2	15	9.5
Serenut 4T	14	10.1	2	8.0	1	40.0	17	11.6
Serenut 5R	1	8.7	0	0	0	0	1	8.7
TOTAL	**184**	**26.4**	**82**	**22.4**	**95**	**25.5**	**361**	**25.2**
Mean Area Planted (acres)								
Land Race	**105**	**0.60**	**44**	**0.64**	**66**	**0.67**	**215**	**0.63**
Red beauty	62	0.54	31	0.59	32	0.55	125	0.56
Igola 1	2	0.65	1	0.25	3	0.76	6	0.64
Erudurudu red	33	0.58	11	0.78	27	0.72	71	0.66
Etesot	22	0.43	3	0.29	7	0.58	32	0.45
Magwere	1	0.25	1	0.13	2	0.25	4	0.22
Kitambi	0	0	0	0	1	0.25	1	0.25
HYRV	**128**	**0.72**	**55**	**0.55**	**49**	**0.70**	**232**	**0.67**
Serenut 1R	1	0.25	0	0.00	0	0.00	1	0.00
Serenut 2	51	0.73	26	0.55	27	0.68	104	0.68
Serenut 3R	3	0.19	4	0.44	1	0.40	8	0.28
Serenut 4 T	8	0.37	2	0.19	0	1.25	10	0.40
Serenut 5R	1	0.25	0	0.00	0	0.00	1	0.25
TOTAL	**184**	**0.84**	**82**	**0.70**	**95**	**0.81**	**361**	**0.80**

Another important consideration in the evaluation of observed patterns for groundnut production is the availability and access to seed. In this case the two primary sources of seed are home saved and the open market, where 46.8% and 43.2% of HHs obtained their seed respectively. Few HHs obtain seed from other sources such as local organizations, multiplication farmers, or seed companies (Table 2). Although 97% of BEN are listed as members of ATU groups (Table A-18), currently only 40% of BEN were found to participate in multiplication of HYRVs, with notably higher levels observed in Mbale (70%) where the ATU offices are located (Table A-19). ATU is responsible for the lion's share (90%) of seed multipliers in the region (Table A-20). Despite these efforts, 90% of respondents indicated no availability for HYRVs (Table 2). The one exception to this is in Tororo where 40% of respondents indicated local availability of HYRVs, again this is likely a feature of location and access to nearby Kenyan markets.

Based on these results, regional producers must rely very heavily on home saved seed for planting. The average number of years HHs save seed is 6 years; for the two main varieties grown, Red beauty and Serenut 2, the averages are 5 and 6.6 years, respectively (Table A-21). However, seed saving is recommended only up to 3 consecutive years, or the equivalent of 6 seasons given regional bimodal rainfall with 2 plantings a year, because of factors such as cross pollination that alter the genetics of the variety over longer periods of time. Yet the limited availability of the new varieties and the cost to purchase seed may explain the observed trend where farmers save seed well beyond the recommended 3 years. Ultimately, this is problematic to the estimation of returns to improved varieties, since at the time of the follow-up survey the average saving period is more than double what is recommended by agronomists, suggesting that the seeds planted may differ considerably from their parent genetics. Furthermore, this observation could very well explain decreased yield from the improved varieties on average when compared to regional test plots at experiment stations.

In terms of new information on HYRVs, about a third of respondents indicated that they heard about new groundnut varieties in the last three years. Most likely this is due to limited access to newly released HYRVs and difficulty in distinguishing such information from other HYRVs that have been promoted for more than a decade up to this point. Additionally, since 2004, 10 new high yielding HYRVs have been released as Serenuts 5R and 6T (2010 releases) which are assumed to be the most widely grown across Uganda (Okello et al. 2016). Awareness and access to these technologies seems to be the root cause and delink among these groups and researchers during both the varietal development process and regional dissemination efforts. It is important to underscore the importance of grower networks, where the main source of information sharing and the dissemination of new technologies is from other HHs, followed by NAADS, and regional radio programing (Table A-22).

Groundnut planting is similar across the study sample, where the average BEN planted 26.4 kg on 0.84 acres, C_IN planted 22.4 kg on 0.70 acres, and the C_OUT group planted 25.5 kg on 0.81 acres (Table 3). However, planting patterns are observed to differ between study groups by variety, where BEN plant less land race varieties and more HYRVs than both the C_IN and C_OUT groups. On average for land race varieties, BEN planted 19.5 kg on 0.6 acres, C_IN planted 21.0 kg on 0.64 acres, and the C_OUT group planted 21.0 kg on 0.67 acres. For improved varieties, on average, BEN planted 22.1 kg on 0.72 acres, C_IN planted 17.2 kg on 0.55 acres, and the C_OUT group planted 21.1 kg on 0.70 acres. Results from a 1-sided t-test for difference in mean area planted indicates significance at the 10% level between BEN and the C_IN group for the following categories: total, improved/hybrid, Erudurudu red, Serenut 2, and Serenut 4. This observed pattern provides some base evidence for differences in adoption of HYRVs between BEN and controls.

The popularity of varieties among growers is consistent with HH taste preferences reported by survey respondents. An alternative explanation of the production patterns however is the reliance on saved seed, which is likely to be associated with a more-or-less fixed production mix. Reasons for variety preferences were therefore assessed in detail during the survey. Respondents were asked to provide the likes and dislikes for each variety grown. Focusing on the three primary varieties, Serenut 2, Red Beauty, and Erudurudu red, we find the primary driver of preference is yield. Other noted characteristics include: drought resistance, rosette resistance, good taste, early maturation, good price, harvesting ease, color, and marketability. However, the perception of high-yield for Erururudu red and red Beauty is not consistent with evidence from local experimental trials (Okello et al. 2015). Yet, these varieties may receive greater on-farm attention from growers because they command a premium price in the markets that are predominantly controlled by the South, East, and Central Uganda, where there is a general preference for red groundnuts. Serenut 2 on the other hand is an HYRV that is tan in color and widely consumed in the eastern and northern regions of Uganda. Across all varieties, good taste and marketability were listed as important characteristics in determining preference, which were listed much more frequently for the two land race varieties than Serenut 2. Other preferences listed for land race varieties, but not for HYRVs, included early maturation, good price, and ease of harvesting.

We observe drought and rosette resistance are not listed as desirable attributes for any of the three main varieties planted (i.e., Serenut 2, Red Beauty, and Erudurudu red). However, in terms of dislikes associated with these varieties, susceptibility to drought and GRD are most commonly listed for the two land race varieties. Serenut 2 on the other hand is not listed as being susceptible to these pressures in the same way, which is expected since it is an HYRV. In fact preference for Serenut 2 is indicated out of a lack of dislikes rather than positive attributes. The popularity of Serenut 2 is likely due to two factors: (1) general variety preference, and (2) the lasting impact of the FGSM program from which HHs have continued to save and plant seed. Non-adoption of the Serenut 1R variety is explained by susceptibility to GRD, and although the variety is designated as improved, in the absence of spraying against aphids it produces low yields.

ii. Adoption of HYRVs

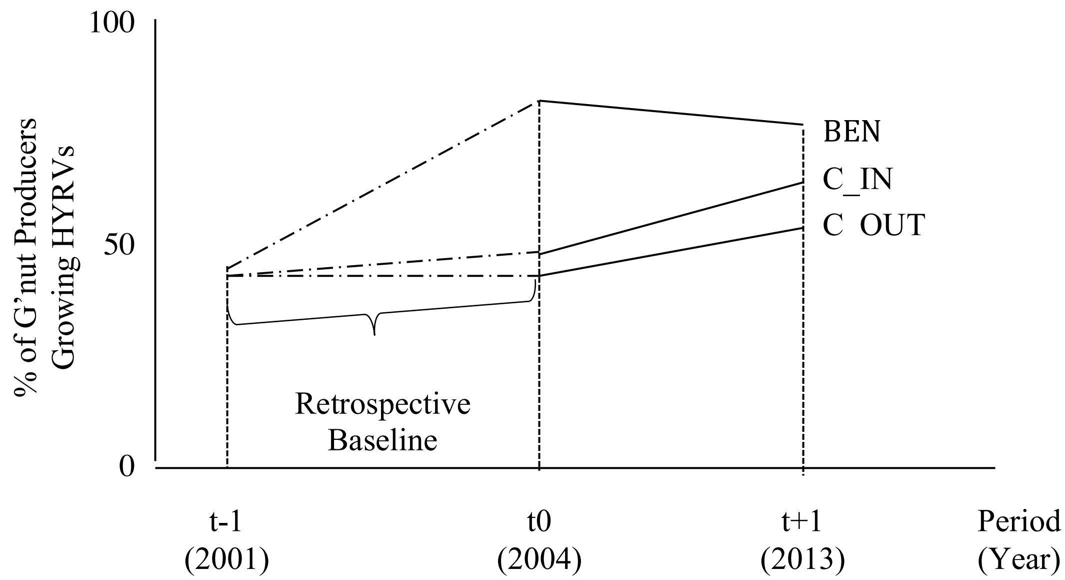

Figure 2. HYRV Adoption Trends by Subgroup: Proportion of Groundnut Producers that Grow HYRVs (2001-2013)

Adoption trends over the last 10 years indicate significant differences between groups. Figure 2 illustrates the proportion of the sample that grows *any* HYRVs by group. The Retrospective Baseline incorporates the key assumption that on average all HHs in the survey region faced the same level of adoption prior to the project, since data is not available for this period. Because BEN were required to grow HYRVs during the project period, as a condition for participation, it is not surprising that some HHs reverted to former production practices (land race varieties) over the 10-year period. Nevertheless, the proportion of HHs using HYRVs remains significantly higher for the BEN group than the controls. The results show that the number of adopters in the beneficiary group decreased over the 10-year period from 78% to 71%, whereas the combined control groups (C_ALL) show a positive trend for adoption from 56% to 63%. The proportion of adopters in the C_IN group increased significantly more over the 10-year period when compared with the C_OUT group, which reflects spillover of project benefits to the C_IN HHs. From 2004 to 2013 the adoption rates for the C_IN group are 60% to 67% compared to 53% to 59% for C_OUT.

Table 4 shows two sets of OLS results for differences in the proportion of total area planted with HYRVs. The first OLS regresses the proportion of groundnuts in HYRVs on the following set of variables: BEN (participation), C_IN (neighbor controls), and a set of covariates (i.e, age, sex, marital status, and education of the HHH, HH sub district, family size, and total area cultivated) (Table A-23). The results indicate +14.2% for BEN and +13.3% for C_IN in comparison to

C_OUT (non-neighbor controls). The second OLS model combines all HHs in project villages (PV) into one group (i.e., PV = BEN + C_IN) and uses the same set of covariates as the first OLS (Table A-24). The results in this case show a +13.9% from all HHs in PVs relative to C_OUT. These estimates are significant either at the 5% or 1% levels. The coefficient estimate for C_IN from the first OLS model is primarily attributed to project spillover; accordingly, the second OLS model includes all members of the project villages as treated (i.e. project beneficiaries).

Table 4. Estimates of the Proportion of Groundnut Production Area in HYRVs: Ordinary Least Squares, Propensity Score Matching, and Instrumental Variables

Model Specification	Coefficient Estimate	Standard Error
OLS(1): BEN	0.142***	0.046
OLS(1): C_IN	0.133**	0.053
OLS(2): PV (BEN + C_IN)	0.139***	0.043
PSM(1): BEN vs. C_ALL	0.072	0.046
PSM(2): BEN vs. C_IN	0.028	0.057
PSM(3): C_IN vs. C_OUT	0.115**	0.054
PSM(4): PV vs. C_OUT	0.135***	0.053
PSM(5): BEN vs. C_OUT	0.215***	0.052
IV: intent-to-treat (ITT)	0.212***	0.067

Note: *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

In order to correct for spillover and selection bias multiple PSM specifications and an Instrumental Variables (IV) model are used. PSM is done, as outlined in section II, for each of the 5 possible group comparisons. A balance test is performed for the first stage estimation results. These results are also examined graphically for common support (Figure A-2). Next the matched sample is regressed using OLS to compare adoption outcomes between the matched groups, the set of covariates included in this second stage regression is the same as the first model, i.e. the LDVM OLS (1). We begin in PSM(1) by matching BEN with C_ALL followed by PSM(2), which is a comparison of BEN and C_IN. Given the prevalence of spillover, these results support the findings that the parameter for BEN is not significant when C_IN is included in the control group specification. Thus, the estimate for the ATE between the BEN and C_IN groups is slightly positive but not statistically significant. By including C_OUT, the magnitude of the ATE estimate increases in size but is also not significantly different from the beneficiary group (Table 4).

In all other cases, where the C_OUT group is used as the sole basis of comparison, we observe statistically significant results. This further illustrates the high level of spillover to HHs within the project villages. We examine the difference between C_IN and C_OUT once more in PSM(3). If the benefits have accrued to the C_IN group, then the associated ATE should be statistically significant, which is indeed the case with an estimated difference of 11.5% and a 5% significance level (Table 4). These results are very similar to the estimates from the second OLS specification (13.3% at the 5% level. PSM(4) results, including the BEN plus C_IN, i.e, PV, as beneficiaries, are very close in magnitude to results from the second OLS estimation (13.5% vs. 13.8%) and both estimates are significant at the 1% level. PSM(5) considers only the BEN and C_OUT groups and the resulting ATE is the largest of all cases considered equal to 21.5% at the 1% significance level.

Next, IV regression is applied given the cross sectional data structure and likely correlation between participation and unobserved variables captured in the error term. Results from the first stage provide evidence that the ITT is a strong instrument having an F-test value of 13.4 (Stock, Wright, and Yogo 2012) (Table A-25). The second stage IV estimate for the effect of the project is 21.2%, which is highly significant at the 1% level (Table A-26) and this is consistent with the PSM(5) results (Table 4). This consistency across results bolsters the robustness of our impact estimates 10 years after the project. Furthermore, the results for spillover effects in program villages are important to illustrate as is the sustainability and extension of program outcomes well after project completion.

iii. Groundnut Productivity, Production Costs, and Sales

HH yields are also evaluated as an important component of our analysis. For the full sample mean HH-level productivity is 249 kg/acre. Differences in productivity between varieties is of particular interest since promotion of HYRVs typically includes the promise of higher yields in addition to drought tolerance and disease resistance. In this case, the opposite is observed, where on average land race varieties produce higher yields than the HYRVs for all groups (Table 5). For the full sample, land race varieties and HYRVs yield 307 kg/acre and 228 kg/acre respectively. The two most widely grown varieties, Serenut 2 and Red Beauty, have average yields of 223 kg/acre and 346 kg/acre respectively. This finding may be consistent with some of the literature on technology adoption, and several studies have provided evidence that producers face lower productivity levels as they adapt to a new technology (Schultz and Strauss 2008). Presumably BEN has both more experience with HYRVs as well as specific training 10-years prior, greater capital accumulation, or deepening, compared to the counterpart groups (Kumar and Russell 2002), which results in a lesser productivity gap between the varieties as compared to the controls. Furthermore, the results are striking because they are not consistent with those recently published by Okello et al. (2015). In the case of Red beauty the average yield in our sample is greater than the maximum yield listed in their recent report. Notably, in no case are average yields for HYRVs in Okello et al. (2015: 19-20) less than land race varieties, whereas the opposite is observed in our sample. This finding may be attributed to the following three factors: 1) greater marketability for red varieties, 2) genetic contamination as a result of seed saving beyond the recommended 3-year period, and 3) increased prevalence of counterfeit seeds (Joughin 2014a; Okello et al. 2015).

Table 5. Quantity Harvested and Yield for Groundnuts by Variety in 2013 (Season A)

	BEN		C_IN		C_OUT		Total	
Quantity Harvested (kg)	Count	Mean	Count	Mean	Count	Mean	Count	Mean
Land Race	**105**	**172**	**44**	**178**	**66**	**164**	**215**	**171**
Red beauty	62	175	31	193	32	174	125	179
Igola 1	2	37	1	40	3	196	6	117
Erudurudu red	33	142	11	153	27	160	71	151
Etesot	22	127	3	36	7	117	32	115
Magwere	1	42	1	14	2	28	4	28
Kitambi	0	0	0	0	1	42	1	42
HYRV	**128**	**112**	**55**	**113**	**49**	**98**	**232**	**109**
Serenut 1R	1	17	0	0	0	0	1	17
Serenut 2	112	107	49	103	45	103	206	105
Serenut 3R	8	85	4	281	2	23	14	133
Serenut 4 T	14	115	1	70	1	100	16	112
Serenut 5R	1	60	0	0	0	0	1	60
TOTAL	**184**	**176**	**82**	**172**	**95**	**165**	**361**	**172**

Mean Yield (kg/acre)								
Land Race	**105**	**313**	**44**	**311**	**66**	**269**	**215**	**299**
Red beauty	62	350	31	374	32	311	125	346
Igola 1	2	69	1	160	3	221	6	160
Erudurudu red	33	302	11	185**	27	231	71	257
Etesot	22	245	3	110**	7	318	32	248
Magwere	1	168	1	112	2	112	4	126
Kitambi	0	0	0	0	1	168	1	168
HYRV	**128**	**265**	**55**	**200****	**49**	**171*****	**232**	**229**
Serenut 1R	1	68	0	0	0	0	1	68
Serenut 2	112	257	49	183**	45	182**	206	223
Serenut 3R	8	557	4	707	2	86**	14	533
Serenut 4T	14	380	1	280	1	80	16	355
Serenut 5R	1	240	0	0	0	0	1	240
TOTAL	**184**	**263**	**82**	**237**	**95**	**233**	**361**	**249**

Note: Significance level is given for the difference in mean yield by category compared to BEN, based on a 1-tailed t-test, *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

A key hypothesis associated with the FGSM project is average productivity increased for HHs that received training from ATU for groundnut production and seed multiplication. In order to test this hypothesis we compare productivity levels for BEN to the control groups, which serve as a counterfactual. We observe significant statistical differences in productivity levels between BEN and control groups, leading us to reject the null hypotheses that no such differences exist. Productivity differences between groups are consistent across all major groundnut varieties and follow the trend that BEN obtains the highest yields on average compared to controls. In the case of HYRVs, the difference is highly significant between BEN vs. both C_IN and C_OUT, with respective average yields of 265 kg/acre compared to 200 kg/acre and 171 kg/acre. The differences in yields between BEN vs. C_IN and C_OUT, i.e. 65kg/acre and 94kg/acre, are significant at the 5% and 1% levels, respectively (Table 5). The smaller difference between BEN and C_IN vs. BEN and C_OUT is in line with the adoption results and is likely the result of diffusion of benefits from training from BEN to C_IN.

Table 6. Average Groundnut Production Costs: Labor by Activity and Other Inputs

	BEN		C_IN		C_OUT		Total	
Labor Input	Days	Cost	Days	Cost	Days	Cost	Days	Cost
Land Prep	21.6	66630	21.3	83671	25.0	29832	22.4	60800
Planting	3.5	33020	3.7	28256	3.5	33131	3.5	31887
Watering	0.0	0	0.0	0	0.0	0	0.0	0
Fertilization	0.0	0	0.0	0	0.0	0	0.0	0
Herbicide*	0.0	261	0.0	0	0.0	0	0.0	134
Spraying	1.2	2893	0.6	1236	0.8	3136	1.0	2584
Weeding 1	37.0	77170	32.7	55885	37.4	43846	36.1	63622
Weeding 2	28.5	52542	31.4	39631	31.8	37574	30.0	45702
Harvest	29.1	51787	29.6	44445	32.1	40080	30.0	47058
Threshing	17.2	24729	11.6	1780	11.5	2708	14.5	13775
Drying	21.9	219.9	20.9	589	21.3	0	21.5	245
Transport	10.9	10561	7.9	1853	11.9	3735	10.5	6807
Other Inputs	N	Cost	N	Cost	N	Cost	N	Cost
Seed (USh/kg)	114	3486	51	3363	64	3419	229	3440
Land Race	*70*	*3511*	*28*	*3323*	*44*	*3461*	*142*	*3459*
HYRV	*62*	*3468*	*30*	*3320*	*29*	*3504*	*121*	*3440*
Insecticide	56	12487	20	11819	38	11565	114	12088
Herbicide	1	24300	0	0	0	0	1	24300
Fertilizer	1	1166	1	650	0	0	2	958
Sprayer	22	5488	10	6347	8	9844	40	6536
Bags	130	26807	53	48297	60	21688	243	29551

*Note: *1 HH in Tororo.*

Production costs for groundnut farmers in the study area are estimated as labor inputs and the amount paid for purchased inputs (Table 6). This is a critical distinction because most growers rely on family labor to limit cash expenses. Labor input is found to be consistent across the three groups of farmers, with weeding, harvesting, and land preparation requiring the greatest amount of worker-days, respectively. The apparent variation in costs between the three groups is due in part to the use of hired labor. Other inputs that are widely used by growers include the purchase of seed and bags for storage. The only chemical input worth noting is insecticide, which is used by a moderate subset of growers (~40%). The overall average cost of producing groundnuts for the farms in the sample is 1,941 USh/kg (Ugandan shilling per kilogram). Across groups the average cost of production (COP) is as follows: BEN 2,034 USh/kg, C_IN 2,066 USh/kg, and C_OUT 1,664 USh/kg. These figures are consistent with recent findings from Okello et al. (2015: 19-20) who report a range in average COP between 1,541 USh/kg and 4,074 USh/kg. As expected, the COP for BEN and C_IN is very similar. On the other hand, the apparent difference between BEN and the C_OUT group is not statistically significant because of considerable variability in COP across HHs.

On average, HHs sell 3,474 kg of groundnuts at a price of USh 2,187/kg (Table 7). BEN sell more on average than C_IN or C_OUT counterparts, with average sales of 3,781 kg, 3,212 kg, and 3,077 kg respectively; Mean prices for unshelled groundnuts are observed to be more consistent across the three groups at USh 2,171/kg, USh 2,067/kg, and USh 2,325/kg, respectively. The value-addition from shelling results in a greater mean value of output equal to USh 3,440/kg averaged across the full sample. This is comparable to the results from Okello et al. (2015), with a range in price from USh 2,400/kg to USh 7,000/kg, where the upper limit of this range is associated with the most recently released HYRVs. Given limited access to cash, these higher prices are prohibitive to the adoption of newly released HYRVs, which explains the prevalence of Serenut 2 and home saved seed.

Table 7. Mean Quantity and Price of Groundnuts Sold in 2013 (Season A)

	BEN		C_IN		C_OUT		Total	
	Mean	N	Mean	N	Mean	N	Mean	N
Quantity (Kg)	3781	128	3212	56	3077	62	3474	246
Price (USh/Kg)	2171	128	2067	57	2325	64	2187	249

Further examination of the relative price difference between groundnut purchased seed and the selling price for unshelled groundnuts indicates additional processing costs for threshing, which is listed as an input in Table 6. The mean cost associated with threshing is 17.2 man-days and 24,729 USh to process a significant portion of the entire crop. This process of value-addition results in the premium price for shelled groundnuts or seed, versus unshelled (Table A-27). Given the mean selling price for unshelled groundnuts at 2,187 USh/kg, in comparison to shelled groundnut seed at 3,440 USh/kg (Tables 6 and 7), we find a clear rational for the use of home saved seed rather than purchased seed as a cost-saving measure. These figures are once more in line with the recent work by Okello et al. (2015). Ultimately, producers rely heavily on family labor and threshing is done simply to prepare their own saved seed for the following season.

Market access is addressed in the survey with 85% of respondents indicating a lack thereof (Table A-28). Sales are predominantly made at the farm gate (~65%) or in the market (~35%) (Table A-29). Once again the Tororo region differs from other districts with +10% greater access to markets given proximity to the Kenya border. One reason listed as a problem with market access is the opportunity cost of bringing product to market given the low prices that are offered there. Most often groundnuts are sold by the bag (35-45 kg of unshelled groundnuts), followed by the basin (7 kg of unshelled groundnuts), and few prefer to sell by kilogram. The last case probably represents the small number of HHs that sell directly to consumers in the market, since groundnuts are almost strictly sold on an individual basis to traders. Most producers sell some of their crop, with only ~10% of HHs that grow strictly for consumption. Groundnuts must be stored until they are either sold or consumed and specific storage and drying practices are assessed in the following section.

iv. Aflatoxin Awareness and Mitigation

On average HHs in our sample store groundnuts for 100 days before selling (Table A-30). This extended period of storage can be problematic if measures are not taken to control for aflatoxin contamination. Best practices must be used beginning in the field through the entire production process and post-harvest (Florkowski and Kolavalli 2013; Okello et al. 2010). Proper storage techniques are thus the final important step in preventing aflatoxin contamination through a series of mitigation practices. Furthermore, the removal and proper disposal of infected groundnuts must be done immediately at the point of detection to prevent further contamination. Identification of aflatoxin-producing mold is thus a critical component to successful mitigation. Yet the main concern is HH-level awareness of aflatoxin and the risks associated with consuming contaminated groundnuts. This key condition must be satisfied before HHs wittingly engage in mitigation practices. We therefore begin by evaluating the awareness of aflatoxin in the region.

In order to gauge aflatoxin awareness, survey respondents were first asked if they had ever heard of aflatoxin. Overall 61% of HHs indicated that they had indeed heard of aflatoxin, and of the 39% that had not heard of aflatoxin by name, when described as "*rotten nuts, moldy, bitter taste*," only 7.5% indicated a lack of awareness (Table A-31). Although we did not directly assess HH awareness of health risks associated with consumption of contaminated nuts, the identification of aflatoxin by name may serve as a loose proxy for this. In sum, 92.5% of HHs surveyed were aware of aflatoxin as a problem affecting groundnuts. Notably, two-thirds of HHs experienced problems with aflatoxin at some point (Table A-32). In 40% of these cases aflatoxin problems only occurred once in 5 years, and 37% were affected in 2 of the last 5 years (Table A-

33). Given problems with aflatoxin contamination, 32% of producers did not report the problem to anyone. For HHs that did report a problem they most often turned to farm group members (21%), neighbors (18%), and extension agents (17%) (Table A-34). Based on discussions and feedback some HHs made changes, the most prevalent being: drying method (28%), storage method (21%), and what to discard (16%) (Table A-35).

The average percentage loss from aflatoxin contamination for affected HHs is 5% of the total harvest (Table A-36). In terms of storage practices, about 60% of affected HHs removed infected nuts before storing, 26% did so sometimes, and 16% did not remove any nuts (Table A-37). When it comes to consumption, 80% of HHs remove contaminated groundnuts and do not eat them, 13% do not remove them before eating sometimes, and 6% do not remove them at all (Table A-38). Removal of contaminated groundnuts before selling is done always by 34% of HHs and sometimes by 36% and the remaining 30% never remove contaminated groundnuts (Table A-39). Strict preference for aflatoxin-free groundnuts among buyers is indicated by 54% of HHs, with only 10% answering sometimes, and 36% of HHs indicating none (Table A-40). In most cases contaminated groundnuts are either thrown away (54%) or fed to animals (36%) (Table A-41). The most important cause of aflatoxin contamination listed by respondents is poor drying (58%) followed by too much rain (19%). When asked about the second most important cause poor storage ranked the highest (36%) (Table A-42). However, 75% of HHs dried groundnuts on the open earth at home with only 3% using a tarpaulin, and 10% on pavement (Table A-43). It is important to note that drying groundnuts along the tarmac roads on pavement is not a recommended practice, though in the case of on-farm drying pavement is a better alternative to the open earth, but clean plastic or tarpaulin is definitively the best practice (Okello et al. 2010). Given poor drying is the primary cause listed for aflatoxin contamination this is a striking result, and we would expect HHs to engage in preventive practices. At the same time farmers are likely to be resource constrained and simply do not have access to tarpaulins or on-farm pavement. The exception to this is Mbale, where 90% of HHs dry groundnuts on pavement, i.e., on the road side, due to an acute land shortage associated with the district's hilly terrain (Table A-43).

Upon further inspection we find several exceptions to the overall trends described above. In the case of aflatoxin awareness respondents from the sub county of Sironko recognized aflatoxin by name in 88% of cases compared to the overall average of 60% (Table A-31). In Mbale 90% of respondents indicated having problems with aflatoxin compared to 65% overall (Table A-32). Geographically, Sironko and Mbale are higher altitude regions with greater precipitation throughout the year and hilly terrain. The process of drying in these regions given the environment is more difficult, and these conditions can greatly increase aflatoxin levels, particularly in groundnuts and maize. In terms of reporting contamination, BEN do so more than either the C_IN or C_OUT control groups, most often turning to fellow group members. HHs from the C_IN group on the other hand are more likely to consult with neighbors than either of the other two groups (Table A-34). Across all groups average losses in Pallisa were greatest and, BEN tended to experience the greatest losses from aflatoxin. This result for Pallisa may be in part due to the greater proportion of HHs (93%) that remove aflatoxin contaminated groundnuts before storage compared to other regions (Table A-36). The perception that buyers always prefer aflatoxin-free groundnuts is strongest by location in Tororo (94%) and by group for BEN (60%) (Table A-39). Because Tororo shares a border with Kenya where aflatoxin awareness is high and buyers dictate the grain quality being bought at market, sale interactions may be informative to producers with respect to aflatoxin contamination.

VI. Summary, Concluding Remarks, and Extensions

After a thorough review of the lasting impacts of the FGSM project it is clear that significant benefits were received by participating producers during the project period and continued through the following decade. This is revealed by notable increases in HH standard of living experienced by beneficiaries as well as groundnut production outcomes. Although some BEN HHs ceased to grow groundnuts, and for that matter HYRVs, we find a 20% difference in adoption levels of HYRVs between HHs that received program benefits and those that did not when we control for spillover and selection bias. Beneficiaries are also observed to be more productive and achieve greater returns than their respective neighbor and non-neighbor controls. Given the long period of time since the conclusion of the project, this finding is important because it illustrates the lasting impact of the efforts undertaken during the FGSM project. The lack of training after 2005 is an important feature of the results, indicating very limited intervention in the region over the last 10 years. On one hand, the project exit strategy allows for a clean evaluation of program effects 10-years later, but on the other regional stakeholders and researchers have cited this feature of the project as being inconsistent with project aims. In retrospect, close work with the National Groundnut Improvement Program at the end of project would have contributed to the continuity of adoption by these valuable groups given the crop improvement agenda. Yet we can infer that the results of our analysis are attributable to the dissemination project because the project is the primary source of regional training over the last 15 years or more, and no additional training was provided by the project following 2005. Furthermore, few HHs obtain seed from other sources such as local organizations, multiplication farmers, or seed companies. In lieu of the original goals set out in the initial project, this result is problematic and requires further inspection.

The sustainability of development interventions is often considered an important objective, but is rarely documented because the data required are simply not available. Our overall findings provide a unique perspective and illustrate the importance and effectiveness of farmer-led extension efforts in Uganda with respect to the adoption of new and improved technologies. Furthermore, the results of our analysis support existing theory regarding the returns to technology adoption in a development context, and are in line with the empirical findings from other recent studies in Uganda (Kassie, Shiferaw, and Muricho 2011; Okello et al. 2015;

Shiferaw et al. 2010; Thuo et al. 2014; Thuo et al. 2013). In addition, we provide a novel contribution to the existing literature on technology adoption by examining the sustainability and lasting impact a decade after the original intervention ended. Our examination of aflatoxin awareness revealed significant knowledge gaps, which clearly demonstrates the need and importance of additional outreach and extension training focusing on proper groundnut handling and storage. Sampling of groundnuts would also be useful to determine the actual prevalence of aflatoxin and contamination levels across producers and throughout the value chain so that interventions can be targeted where they are most needed. As a final note, it is important to further examine and address concerns over counterfeit seeds in the marketplace as well as the need for continued support to local farmers through extension services (Joughin 2014a; Benin et al. 2011). Increased affordability of seeds, quality assurance and monitoring efforts for seed producers, and extension services to farmers are important tools to promote the sustainability of groundnut farming in Uganda.

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Appendix A. Additional Tables and Figures

Table A-1. HH Family Composition by Project Groups and Groundnut Participation

	BEN		C_IN		C_OUT		Total	
Sex/Age Group	N	Mean	N	Mean	N	Mean	N	Mean
Total HH Members	240	8.2	120	8.4	120	9.0	480	8.5
Child		2.2		2.2		2.5		2.3
Youth		1.9		1.8		2.2		2.0
Adult		3.6		3.9		4.0		3.8
Elder		0.5		0.5		0.3		0.5
Male		4.1		4.3		4.6		4.3
Child		1.1		1.3		1.3		1.2
Youth		1.0		0.9		1.1		1.0
Adult		1.8		1.8		2.0		1.9
Elder		0.3		0.2		0.1		0.2
Female		4.1		4.1		4.5		4.2
Child		1.1		1.0		1.1		1.1
Youth		0.9		0.8		1.2		1.0
Adult		1.8		2.0		2.0		1.9
Elder		0.3		0.3		0.2		0.2
Participating in Groundnut Farming								
Child		0.4		0.4		0.4		0.4
Youth		1.6		1.5		1.8		1.6
Adult		3.4		3.6		3.7		3.5
Elder		0.5		0.4		0.3		0.4
Male		2.9		3.0		3.0		2.9
Child		0.2		0.3		0.2		0.2
Youth		0.8		0.8		0.9		0.8
Adult		1.6		1.8		1.8		1.7
Elder		0.3		0.2		0.1		0.2
Female		3.0		3.0		3.2		3.0
Child		0.2		0.2		0.2		0.2
Youth		0.8		0.7		1.0		0.8
Adult		1.7		1.9		1.9		1.8
Elder		0.2		0.2		0.1		0.2
Not Participating in Groundnut Farming								
Male		0.9		1.0		1.2		1.0
Child		0.2		0.2		0.2		0.2
Youth		0.2		0.1		0.2		0.2
Adult		0.0		0.0		0.0		0.0
Elder		0.9		0.8		1.0		0.9
Female		0.2		0.1		0.2		0.1
Child		0.1		0.1		0.1		0.1
Youth		0.0		0.0		0.1		0.0
Adult		0.9		1.0		1.2		1.0
Elder		0.2		0.2		0.2		0.2

Table A-2. Sex of Survey Respondent

	BEN		C_IN		C_OUT		Total	
Sex of Respondent	Count	%	Count	%	Count	%	Count	%
Male	97	40.4	66	55.0	76	63.3	239	49.8
Female	143	59.6	54	45.0	44	36.7	241	50.2
Total	240	100.0	120	100.0	120	100.0	480	100.0

Table A-3. Sex of Head of Household for Full Sample by Sex of Respondent

Sex of Head of Household	BEN		C_IN		C_OUT		Total	
by Sex of Respondent	Count	Mean	Count	Mean	Count	Mean	Count	Mean
Male	*189*	*78.8*	*93*	*77.5*	*97*	*80.8*	*379*	*79.0*
Female	93	49.2	19	20.7	35	36.1	147	38.8
Male	96	50.8	74	79.6	62	63.9	232	61.2
Female	*51*	*21.3*	*27*	*22.5*	*23*	*19.2*	*101*	*21.0*
Female	50	98.0	25	92.6	19	82.6	94	93.1
Male	1	2.0	2	7.4	4	17.4	7	6.9

Table A-4. Marital Status of HHH

	BEN		C_IN		C_OUT		Total	
Marital Status	Count	%	Count	%	Count	%	Count	%
Single	4	1.7	2	1.7	3	2.5	9	1.9
Married	191	79.6	100	83.3	104	86.7	395	82.3
Widowed	43	18.0	17	14.2	12	10.0	72	15.0
Divorced/ Separated	2	0.8	1	0.8	1	0.8	4	0.8

Table A-5. Formal Education of HHH

	BEN		C_IN		C_OUT		Total	
Education Level	Count	%	Count	%	Count	%	Count	%
No Formal Schooling	36	15.0	15	12.5	14	11.7	65	13.4
Primary	128	53.6	77	64.2	65	54.2	270	56.4
Secondary	49	20.5	21	17.5	32	26.7	102	21.3
Tertiary	27	11.3	7	5.8	9	7.5	43	9.0

Table A-6. Age of HHH

Age Class (Range)	BEN	C_IN	C_OUT	Total
35 year and below	18	21	14	53
36-40 years	24	11	18	53
41-45 years	24	15	17	56
46-50 years	42	22	21	85
51-55 years	30	12	17	59
56-60 years	45	13	17	75
Above 60 years	57	26	16	99

Table A-7. HH Total Farm Size Range in 2013 by Sub-County

Acres Range	<0.5		0.5 – 1		1 – 3		3 – 5		>5	
	N	%	N	%	N	%	N	%	N	%
Full Sample	6	1.3	23	4.8	173	36.0	164	34.2	114	23.8
Bukhalu	2	3.3	6	10.0	34	56.7	12	20.0	6	10.0
Butiru	0	0.0	1	1.7	13	21.7	26	43.3	20	33.3
Kachonga	2	3.3	2	3.3	35	58.3	12	20.0	9	15.0
Kasodo	1	1.7	6	10.0	14	23.3	24	40.0	15	25.0
Kidongole	0	0.0	1	1.7	16	26.7	25	41.7	18	30.0
Lyama	0	0.0	6	10.0	32	53.3	11	18.3	11	18.3
Nagongera	1	1.7	0	0.0	10	16.7	28	46.7	21	35.0
Nyero	0	0.0	1	1.7	19	31.7	26	43.3	14	23.3
BEN	2	0.8	13	5.4	85	35.4	87	36.3	53	22.1
Bukhalu	1	3.3	2	6.7	18	60.0	5	16.7	4	13.3
Butiru	0	0.0	1	3.3	5	16.7	14	46.7	10	33.3
Kachonga	0	0.0	2	6.7	18	60.0	8	26.7	2	6.7
Kasodo	1	3.3	3	10.0	9	30.0	11	36.7	6	20.0
Kidongole	0	0.0	1	3.3	7	23.3	12	40.0	10	33.3
Lyama	0	0.0	4	13.3	13	43.3	7	23.3	6	20.0
Nagongera	0	0.0	0	0.0	8	26.7	15	50.0	7	23.3
Nyero	0	0.0	0	0.0	7	23.3	15	50.0	8	26.7
C_IN	3	2.5	7	5.8	50	41.7	37	30.8	23	19.2
Bukhalu	0	0.0	3	20.0	7	46.7	4	26.7	1	6.7
Butiru	0	0.0	0	0.0	6	40.0	7	46.7	2	13.3
Kachonga	2	13.3	0	0.0	9	60.0	1	6.7	3	20.0
Kasodo	0	0.0	2	13.3	5	33.3	6	40.0	2	13.3
Kidongole	0	0.0	0	0.0	7	46.7	5	33.3	3	20.0
Lyama	0	0.0	2	13.3	9	60.0	2	13.3	2	13.3
Nagongera	1	6.7	0	0.0	0	0.0	6	40.0	8	53.3
Nyero	0	0.0	0	0.0	7	46.7	6	40.0	2	13.3
C_OUT	1	0.8	3	2.5	38	31.7	40	33.3	38	31.7
Bukhalu	1	6.7	1	6.7	9	60.0	3	20.0	1	6.7
Butiru	0	0.0	0	0.0	2	13.3	5	33.3	8	53.3
Kachonga	0	0.0	0	0.0	8	53.3	3	20.0	4	26.7
Kasodo	0	0.0	1	6.7	0	0.0	7	46.7	7	46.7
Kidongole	0	0.0	0	0.0	2	13.3	8	53.3	5	33.3
Lyama	0	0.0	0	0.0	10	66.7	2	13.3	3	20.0
Nagongera	0	0.0	0	0.0	2	13.3	7	46.7	6	40.0
Nyero	0	0.0	1	6.7	5	33.3	5	33.3	4	26.7

Table A-8. Average Total Area Cultivated by HH in 2013 Season A by Sub-County

Total Acres	<0.5		0.5 – 1		1 – 3		3 – 5		>5		Total	
	N	%	N	%	N	%	N	%	N	%	N	Mean
Full Sample	6	1.4	23	4.9	173	36.1	164	34.3	114	23.9	480	3.74
Bukhalu	2	3.3	6	11.1	34	56.8	12	20.6	6	11.1	60	3.23
Butiru	0	0.0	1	3.3	13	22.9	26	43.6	20	33.3	60	4.08
Kachonga	2	6.7	2	6.7	35	58.4	12	22.2	9	19.6	60	3.40
Kasodo	1	3.3	6	10.0	14	25.3	24	40.3	15	26.0	60	3.77
Kidongole	0	0.0	1	3.3	16	27.1	25	41.7	18	30.4	60	4.00
Lyama	0	0.0	6	11.1	32	55.2	11	19.7	11	18.5	60	3.45
Nagongera	1	3.3	0	0.0	10	22.7	28	46.9	21	38.9	60	4.13
Nyero	0	0.0	1	3.3	19	33.8	26	44.4	14	23.8	60	3.88
BEN	2	0.8	13	5.4	85	35.4	87	36.3	53	22.1	240	3.73
Bukhalu	1	3.3	2	6.7	18	60.0	5	16.7	4	13.3	30	3.30
Butiru	0	0.0	1	3.3	5	16.7	14	46.7	10	33.3	30	4.10
Kachonga	0	0.0	2	6.7	18	60.0	8	26.7	2	6.7	30	3.33
Kasodo	1	3.3	3	10.0	9	30.0	11	36.7	6	20.0	30	3.60
Kidongole	0	0.0	1	3.3	7	23.3	12	40.0	10	33.3	30	4.03
Lyama	0	0.0	4	13.3	13	43.3	7	23.3	6	20.0	30	3.50
Nagongera	0	0.0	0	0.0	8	26.7	15	50.0	7	23.3	30	3.97
Nyero	0	0.0	0	0.0	7	23.3	15	50.0	8	26.7	30	4.03
Non Benef	4	1.7	10	4.2	88	36.7	77	32.1	61	25.4	240	3.75
Bukhalu	1	3.3	4	13.3	16	53.3	7	23.3	2	6.7	30	3.17
Butiru	0	0.0	0	0.0	8	26.7	12	40.0	10	33.3	30	4.07
Kachonga	2	6.7	0	0.0	17	56.7	4	13.3	7	23.3	30	3.47
Kasodo	0	0.0	3	10.0	5	16.7	13	43.3	9	30.0	30	3.93
Kidongole	0	0.0	0	0.0	9	30.0	13	43.3	8	26.7	30	3.97
Lyama	0	0.0	2	6.7	19	63.3	4	13.3	5	16.7	30	3.40
Nagongera	1	3.3	0	0.0	2	6.7	13	43.3	14	46.7	30	4.30
Nyero	0	0.0	1	3.3	12	40.0	11	36.7	6	20.0	30	3.73

Table A-9. Average Rank of Staple Food Consumption

	BEN		C_IN		C_OUT		Total	
Staple Food Item	Count	Rank	Count	Rank	Count	Rank	Count	Rank
Meat (without gnuts)	240	2.54	120	2.60	119	2.48	479	2.54
Chicken (without gnuts)	240	3.07	120	3.28	120	3.13	480	3.14
Fish (without gnuts)	240	2.21	120	2.24	120	2.27	480	2.23
Cowpeas (without gnuts)	233	2.93	117	3.08	115	2.97	465	2.98
Beans (without gnuts)	240	1.75	119	1.76	120	1.61	479	1.72
Grams (without gnuts)	233	3.48	118	3.57	115	3.65	466	3.54
Greens (without gnuts)	240	1.43	118	1.48	120	1.42	478	1.44
Groundnuts (binyewa)	240	2.26	118	2.14	119	2.14	477	2.20
Groundnuts (with other)	238	1.97	119	1.93	119	1.89	476	1.94

Table A-10. Primary Crops Grown by area for Beneficiaries and Controls in 2013

Beneficiaries		Maize	Beans	Cassava	Cotton	Gnuts	Millet	Potatoes	Sorghum
Total	Count	177	98	166	16	187	99	70	44
	%	74.4	41.2	69.7	6.7	78.6	41.6	29.4	18.5
	Rank	2.4	3.0	2.4	3.2	2.3	2.8	4.0	3.7
Kumi	Count	26	5	47	6	60	28	14	11
	%	43.3	8.3	78.3	10	100	46.7	23.3	18.3
	Rank	1.0	3.5	2.5	3.5	1.8	2.6	3.3	3.3
Pallisa	Count	42	16	36	2	47	31	1	22
	%	71.2	27.1	61	3.4	79.7	52.5	1.7	37.3
	Rank	1.2	2.7	3.0	3.0	2.5	2.7	3.9	4.1
Tororo	Count	56	39	47	1	39	29	29	8
	%	93.3	65	78.3	1.7	65	48.3	48.3	13.3
	Rank	2.2	3.0	2.7	3.3	2.2	2.9	4.4	4.1
Mbale	Count	26	28	28	0	26	10	20	3
	%	86.7	93.3	93.3	0	86.7	33.3	66.7	10
	Rank	3.0	4.1	1.6	2.7	2.5	2.8	4.2	3.2
Sironko	Count	27	10	8	7	15	1	6	0
	%	93.1	34.5	27.6	24.1	51.7	3.4	20.7	0
	Rank	3.7	2.7	2.1	4.0	2.6	2.9	4.0	3.7
Controls									
Total	Count	178	95	157	9	174	108	67	50
	%	74.8	39.9	66	3.8	73.1	45.6	28.2	21
	Rank	1.2	2.8	2.8	2.8	2.4	2.8	3.9	3.4
Kumi	Count	28	1	48	2	53	34	19	9
	%	46.7	1.7	80	3.3	88.3	56.7	31.7	15
	Rank	1.0	2.9	2.2	3.0	1.7	2.5	3.5	3.3
Pallisa	Count	43	15	33	1	48	36	11	26
	%	71.7	25	55	1.7	80	61	18.3	43.3
	Rank	1.1	3.1	2.9	2.7	2.9	2.6	4.0	3.5
Tororo	Count	51	40	42	3	34	26	20	13
	%	87.9	69	72.4	5.2	58.6	44.8	34.5	22.4
	Rank	1.0	2.5	3.4	2.3	3.1	3.4	4.1	3.0
Mbale	Count	27	28	27	0	19	11	15	2
	%	90	93.3	90	0	63.3	36.7	50	6.7
	Rank	1.4	2.7	2.7	0.0	3.1	3.2	4.3	4.3
Sironko	Count	29	11	7	3	20	1	2	0
	%	96.7	36.7	23.3	10	66.7	3.3	6.7	0
	Rank	1.5	2.6	3.4	2.6	1.8	3.9	3.4	0.0

Table A-11. Crops Ranked by Income for BEN and Control HHs in 2013

BEN		Maize	O. Leg	Cas'va	Cot'n	Gnuts	Millet	Potat.	Sorgh.	Rice
Total	Count	171	143	146	24	173	88	59	58	54
	%	71.8	60.1	61.3	10.1	72.7	37.0	24.8	24.4	22.7
	Rank	2.1	3.1	3.2	3.1	2.4	1.1	4.3	4.3	2.0
Kumi	Count	36	29	47	10	54	32	19	17	7
	%	60.0	48.3	78.3	16.7	90.0	53.3	31.7	28.3	11.7
	Rank	2.4	3.7	3.3	2.3	2.1	1.4	4.0	4.1	3.1
Pallisa	Count	34	19	19	1	44	23	0	15	18
	%	57.6	32.2	32.2	1.7	74.6	39.0	0.0	25.4	30.5
	Rank	2.2	3.2	2.6	1.0	2.2	0.9	0.0	2.7	1.2
Tororo	Count	50	43	42	5	39	19	16	14	28
	%	83.3	71.7	70.0	8.3	65.0	31.7	26.7	23.3	46.7
	Rank	2.4	3.7	3.1	6.8	1.9	1.1	4.8	4.9	2.0
Mbale	Count	26	30	29	1	25	14	19	12	1
	%	86.7	100.0	96.7	3.3	83.3	46.7	63.3	40.0	3.3
	Rank	1.4	2.1	3.4	6.0	3.9	2.4	4.5	5.8	7.0
Sironko	Count	25	22	9	7	11	0	5	0	0
	%	86.2	75.9	31.0	24.1	37.9	0.0	17.2	0.0	0.0
	Rank	1.4	2.5	3.7	2.1	2.4	0.0	3.2	0.0	0.0
Controls										
Total	Count	168	128	126	18	170	103	45	36	61
	%	70.6	53.8	52.9	7.6	71.4	43.3	18.9	15.1	25.6
	Rank	2.0	2.8	3.1	3.2	2.4	1.1	3.9	4.0	1.7
Kumi	Count	30	24	43	7	49	37	20	8	6
	%	50.0	40.0	71.7	11.7	81.7	61.7	33.3	13.3	10.0
	Rank	2.0	3.3	3.0	3.1	2.3	1.3	2.9	4.3	1.7
Pallisa	Count	38	15	18	3	47	34	1	15	14
	%	63.3	25.0	30.0	5.0	78.3	56.7	1.7	25.0	23.3
	Rank	2.1	3.1	2.6	2.7	1.7	1.3	5.0	3.4	1.1
Tororo	Count	44	34	33	5	31	20	5	10	38
	%	75.9	58.6	56.9	8.6	53.4	34.5	8.6	17.2	65.5
	Rank	2.6	3.5	3.4	4.2	2.6	1.1	5.2	4.3	1.7
Mbale	Count	28	28	26	0	22	11	19	3	3
	%	93.3	93.3	86.7	0.0	73.3	36.7	63.3	10.0	10.0
	Rank	1.5	2.1	3.3	0.0	4.1	1.6	4.6	5.7	5.0
Sironko	Count	28	27	6	3	21	1	0	0	0
	%	93.3	90.0	20.0	10.0	70.0	3.3	0.0	0.0	0.0
	Rank	1.6	2.1	3.5	2.3	2.1	0.1	0.0	0.0	0.0

Table A-12. Change in Groundnut Area Planted from 2004 to 2013

Change in Area of Groundnuts Planted	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
2004 Proportion of 2013	189	89.4	83	88.6	96	92.2	368	89.9
Total								
Increased	98	51.3	44	52.4	50	52.1	192	51.8
Decreased	69	36.1	31	36.9	34	35.4	134	36.1
Remained the Same	24	12.6	9	10.7	12	12.5	45	12.1
Kumi								
Increased	23	38.3	7	26.9	19	70.4	49	43.4
Decreased	28	46.7	13	50.0	4	14.8	45	39.8
Remained the Same	9	15.0	6	23.1	4	14.8	19	16.8
Pallisa								
Increased	20	42.6	9	47.4	10	34.5	39	41.1
Decreased	14	29.8	8	42.1	11	37.9	33	34.7
Remained the Same	13	27.7	2	10.5	8	27.6	23	24.2
Tororo								
Increased	32	80.0	15	88.2	14	87.5	61	83.6
Decreased	8	20.0	2	11.8	2	12.5	12	16.4
Remained the Same	0	0.0	0	0.0	0	0.0	0	0.0
Mbale								
Increased	16	55.2	5	41.7	3	23.1	24	44.4
Decreased	11	37.9	7	58.3	10	76.9	28	51.9
Remained the Same	2	6.9	0	0.0	0	0.0	2	3.7
Sironko								
Increased	7	46.7	8	80.0	4	36.4	19	52.8
Decreased	8	53.3	1	10.0	7	63.6	16	44.4
Remained the Same	0	0.0	1	10.0	0	0.0	1	2.8

Note: Only HHs that produced gnuts in both 2004 and 2013 are considered in the analysis.

Table A-13. Reasons for NOT Growing Groundnuts

Why does HH NOT grow Groundnuts?	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
No money for seed	21	16.5	21	27.3	7	10.3	49	18.0
No money to rent land	3	2.4	5	6.5	3	4.4	11	4.0
Sickness	7	5.5	2	2.6	0	0.0	9	3.3
Limited land	2	1.6	2	2.6	1	1.5	5	1.8
Labor intensive	2	1.6	2	2.6	1	1.5	5	1.8

Table A-14. Groundnut Growers in 2013 by Farmer Category and District

	BEN		C_IN		C_OUT		Total	
Category/ District	Count	%	Count	%	Count	%	Count	%
Total	191	79.6	84	70.0	98	81.7	373	77.7
Kumi	60	100.0	26	86.7	27	90.0	113	94.2
Pallisa	47	78.3	19	63.3	29	96.7	95	79.2
Tororo	40	66.7	17	56.7	18	60.0	75	62.5
Mbale	29	96.7	12	80.0	13	86.7	54	90.0
Sironko	15	50.0	10	66.7	11	73.3	36	60.0
Groundnut Grower								
Male HHH	83	43.7	44	52.4	44	44.9	171	25.9
Female HHH	170	89.0	67	55.8	88	89.8	325	49.3
Male Youth	39	20.4	23	27.4	27	27.6	89	13.5
Female Youth	33	17.3	18	21.4	23	23.5	74	11.2
Groundnut Income Decision								
Male HHH	22	9.2	11	9.2	9	7.5	42	8.8
Female HHH	39	16.3	16	13.3	9	7.5	64	13.3
Joint HHH	118	49.2	53	44.2	64	53.3	235	49.0
Not Applicable	61	25.4	40	33.3	38	31.7	139	29.0

Table A-15. Major Challenges to Growing Groundnuts, Responses, and Solutions

	BEN		C_IN		C_OUT		Total	
Major Challenge	Count	%	Count	%	Count	%	Count	%
Lack of land	18	8.7	5	4.7	3	2.8	26	6.2
Lack of operating capital	40	19.4	18	17.0	25	23.4	83	19.8
Drought	65	31.6	20	18.9	38	35.5	123	29.4
Too much rain	20	9.7	3	2.8	8	7.5	31	7.4
Pests and disease	56	27.2	22	20.8	31	29.0	109	26.0
Expensive inputs	23	11.2	7	6.6	10	9.3	40	9.5
Labor: intensive/no hired	33	16.0	16	15.1	18	16.8	67	16.0
Rodents eat Gnuts in field	12	5.8	5	4.7	8	7.5	25	6.0
Poor/bad weather	16	7.8	15	14.2	12	11.2	43	10.3
Low market price	9	4.4	1	0.9	1	0.9	11	2.6
Response to Challenges								
Rent more land	10	5.2	6	6.2	4	4.2	20	5.2
Early/ timely planting	59	30.4	22	22.7	39	40.6	120	31.0
Spraying (timely)	26	13.4	6	6.2	24	25.0	56	14.5
Resistant varieties	23	11.9	4	4.1	15	15.6	42	10.9
Use hired labor	11	5.7	8	8.2	4	4.2	23	5.9
Use group labor	7	3.6	4	4.1	3	3.1	14	3.6
Rotational saving*	24	12.4	6	6.2	12	12.5	42	10.9

*Note: *Joined with local SACCOs*

Table A-16. Adoption of Recommended Improved Groundnut Growing Practices

	BEN		C_IN		C_OUT		Total	
Improved Practice	Count	%	Count	%	Count	%	Count	%
Site Selection								
Full	156	81.7	69	81.2	90	90.9	315	84.0
Partial	13	6.8	3	3.5	1	1.0	17	4.5
None	22	11.5	13	15.3	8	8.1	43	11.5
Land Preparation								
Full	188	97.9	85	100.0	99	100.0	372	98.9
Partial	4	2.1	0	0.0	0	0.0	4	1.1
Timely Planting								
Full	175	91.6	83	97.6	95	96.9	353	94.4
Partial	16	8.4	2	2.4	3	3.1	21	5.6
Spacing								
Full	82	42.7	27	32.1	31	31.3	140	37.3
Partial	73	38.0	26	31.0	29	29.3	128	34.1
None	37	19.3	31	36.9	39	39.4	107	28.5
Improved Variety								
Full	162	86.2	74	91.4	78	78.8	314	85.3
Partial	18	9.6	2	2.5	9	9.1	29	7.9
None	8	4.3	5	6.2	12	12.1	25	6.8
Weed Control								
Full	180	93.8	77	90.6	97	98.0	354	94.1
Partial	12	6.3	8	9.4	2	2.0	22	5.9
Pest Control								
Full	69	37.3	30	35.3	40	40.4	139	37.7
Partial	24	13.0	10	11.8	11	11.1	45	12.2
None	92	49.7	45	52.9	48	48.5	185	50.1
Fertilizer Use								
Full	7	3.7	3	3.6	6	6.2	16	4.3
Partial	17	9.0	5	6.0	8	8.2	30	8.1
None	165	87.3	76	90.5	83	85.6	324	87.6
Timely Harvest								
Full	174	93.0	80	96.4	94	96.9	348	94.8
Partial	12	6.4	3	3.6	2	2.1	17	4.6
None	1	0.5	0	0.0	1	1.0	2	0.5
Proper Drying								
Full	184	95.8	82	96.5	97	98.0	363	96.5
Partial	7	3.6	2	2.4	2	2.0	11	2.9
None	1	0.5	1	1.2	0	0.0	2	0.5
Proper Storage								
Full	166	86.9	74	88.1	88	88.9	328	87.7
Partial	18	9.4	3	3.6	7	7.1	28	7.5
None	7	3.7	7	8.3	4	4.0	18	4.8

Table A-17. Training in Groundnut Production and Seed Multiplication

Training in Groundnut Production	BEN Count	BEN %	C_IN Count	C_IN %	C_OUT Count	C_OUT %	Total Count	Total %
Total	186	78.3	30	29.5	25	36.3	241	52.5
Kumi	43	71.7	6	20.0	6	20.0	55	45.8
Before 2005	37	86.0	1	16.7	1	16.7	39	70.9
2005 – 2012	13	31.0	5	83.3	6	100.0	24	44.4
During 2013	0	0.0	0	0.0	1	16.7	1	1.8
Pallisa	47	78.3	5	16.7	3	10.0	55	45.8
Before 2005	47	100.0	1	20.0	1	33.3	49	89.1
2005 – 2012	3	6.5	4	80.0	3	100.0	10	18.5
During 2013	2	4.3	1	20.0	0	0.0	3	5.5
Tororo	54	90.0	13	43.3	15	50.0	82	68.3
Before 2005	54	100.0	12	92.3	13	86.7	79	96.3
2005 – 2012	8	14.8	0	0.0	3	20.0	11	13.4
During 2013	7	13.0	1	7.7	0	0.0	8	9.8
Mbale	20	66.7	3	20.0	1	6.7	24	40.0
Before 2005	19	95.0	2	66.7	0	0.0	21	87.5
2005 – 2012	22	100.0	3	100.0	0	0.0	25	100.0
During 2013	3	15.0	1	33.3	0	0.0	4	16.7
Sironko	22	73.3	3	20.0	0	0.0	25	41.7
Before 2005	22	100.0	3	100.0	0	0.0	25	100.0
2005 – 2012	1	4.5	0	0.0	0	0.0	1	4.0
Seed Multiplication								
Total	165	68.7	24	20.0	17	14.2	206	42.9
Kumi	20	33.3	2	6.7	0	0.0	22	18.3
Before 2005	19	95.0	1	50.0	0	0.0	20	92.8
2005 – 2012	3	15.0	1	50.0	0	0.0	4	23.8
During 2013	0	0.0	0	0.0	0	0.0	0	0.0
Pallisa	47	78.3	5	16.7	4	13.3	56	46.7
Before 2005	46	97.9	1	20.0	1	25.0	48	94.8
2005 – 2012	3	6.4	4	80.0	4	100.0	11	67.2
During 2013	2	4.3	1	20.0	0	0.0	3	9.5
Tororo	56	93.3	13	43.3	12	40.0	81	67.5
Before 2005	56	100.0	12	92.3	10	83.3	78	96.7
2005 – 2012	6	11.1	0	0.0	3	25.0	9	15.7
During 2013	6	10.9	1	7.7	0	0.0	7	10.4
Mbale	23	76.7	3	20.0	1	6.7	27	45.0
Before 2005	23	100.0	2	66.7	0	0.0	25	97.3
2005 – 2012	9	39.1	2	66.7	1	100.0	12	48.8
During 2013	2	8.7	0	0.0	0	0.0	2	8.7
Sironko	19	63.3	1	6.7	0	0.0	20	33.3
Before 2005	19	100.0	1	100.0	0	0.0	20	100.0
2005 – 2012	0	0.0	0	0.0	0	0.0	0	0.0

Note: Sironko production and multiplication training in 2013 omitted because of 0 value.

Table A-18. ATU Membership by District

Proportion Membership of ATU Group(s)	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
Total	232	96.7	23	19.2	36	30.0	291	60.6
Kumi	59	98.3	6	20.0	6	20.0	71	59.2
Pallisa	60	100.0	3	10.0	8	26.7	71	59.2
Tororo	57	95.0	12	40.0	12	40.0	81	67.5
Mbale	29	96.7	0	0.0	10	66.7	39	65.0
Sironko	27	90.0	2	13.3	0	0.0	29	48.3

Table A-19. Groundnut Farmer Seed Multiplication

Seed Multiplication by District	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
Total	96	40.0	6	5.0	7	5.8	109	22.7
Kumi	16	26.7	1	3.3	0	0.0	17	14.2
Pallisa	28	46.7	3	10.0	6	20.0	37	30.8
Tororo	22	36.7	0	0.0	1	3.3	23	19.2
Mbale	21	70.0	2	13.3	0	0.0	23	38.3
Sironko	9	30.0	0	0.0	0	0.0	9	15.0

Table A-20. Total Multiplier HHs and Mean HYRV Seed Produced (kg) (2013 Season A)

	BEN		C_IN		C_OUT		Total	
Company/Organization	N	Mean	N	Mean	N	Mean	N	Mean
Total	96	138.8	5	129.5	7	132.3	108	137.9
ATU	95	139.0	2	182.0	0	0.0	97	139.9
Butove	0	0.0	0	0.0	2	21.0	2	21.0
CCF	0	0.0	0	0.0	10	1.0	10	1.0
DFA	0	0.0	1	52.5	0	0.0	1	52.5
NAADS	1	120.0	2	115.5	4	218.5	7	175.0

Table A-21. Seed Saving: Average Number of Years of Seed Saving by Variety

	BEN		C_IN		C_OUT		Total	
*Category/Variety**	N	Mean	N	Mean	N	Mean	N	Mean
Land Race	31	4.1	12	4.1	23	6.6	66	5.0
Red beauty	20	3.7	10	4.0	6	5.5	36	4.1
Erudurudu red	7	5.4	0	0.0	12	5.7	19	5.6
Old variety	3	4.3	1	6.0	4	11.2	8	8.0
HYRV	63	7.4	20	6.0	17	3.7	100	6.5
Serenut 2	58	7.6	20	6.0	17	3.6	95	6.6
TOTAL	94	6.3	32	5.3	40	5.3	166	5.9

**Varieties with N<5 excluded: Igola1, & Serenut1,3,4,5.*

Table A-22. Dissemination of New Varieties by District

Heard of Improved Gnut Varieties in last 3 years	BEN Count	BEN %	C_IN Count	C_IN %	C_OUT Count	C_OUT %	Total Count	Total %
Total								
No	156	65.0	78	65.0	72	60.0	306	63.75
Yes	84	35.0	42	35.0	48	40.0	174	36.25
Kumi								
No	37	61.7	22	73.3	19	63.3	78	65.0
Yes	23	38.3	8	26.7	11	36.7	42	35.0
Pallisa								
No	42	70.0	18	60.0	20	66.7	80	66.7
Yes	18	30.0	12	40.0	10	33.3	40	33.3
Tororo								
No	34	56.7	16	53.3	16	53.3	66	55.0
Yes	26	43.3	14	46.7	14	46.7	54	45.0
Mbale								
No	26	86.7	15	93.8	12	85.7	53	88.3
Yes	4	13.3	1	6.3	2	14.3	7	11.7
Sironko								
No	17	56.7	7	50.0	5	31.3	29	48.3
Yes	13	43.3	7	50.0	11	68.8	31	51.7
Information Source								
NAADS	27	32.1	13	30.2	15	31.9	55	31.6
Serere/NARO	3	3.6	0	0.0	0	0.0	3	1.7
VECO	0	0.0	0	0.0	0	0.0	0	0.0
Self Help Africa	1	1.2	1	2.3	0	0.0	2	1.1
Other NGO	4	4.8	0	0.0	0	0.0	4	2.3
Farmer's Association	3	3.6	0	0.0	0	0.0	3	1.7
Makerere	0	0.0	1	2.3	2	4.3	3	1.7
Other farmers	56	66.7	30	69.8	33	70.2	119	68.4
Radio	20	23.8	9	20.9	10	21.3	39	22.4
Jinja Show	0	0.0	0	0.0	0	0.0	0	0.0
Others	3	3.6	3	7.0	1	2.1	7	4.0
Not applicable	7	8.3	3	7.0	4	8.5	14	8.0

Table A-23. OLS Regression Estimates for the Proportion of Groundnut Production Area in HYRVs: (1) BEN and C_IN

Variable	Coefficient Estimate	Standard Error
BEN	0.1420***	0.0456
C_IN	0.1330**	0.0525
HHH_AGE	0.0008	0.0015
HHH_MALE	0.0678	0.0685
MSTAT_MARIED	-0.0139	0.1311
MSTAT_WIDO	-0.0480	0.1339
RESP_MALE	0.0385	0.0438
EDU_PRIM	0.0649	0.0600
EDU_SEC	0.0063	0.0690
EDU_TERT	0.1356	0.0835
SUB_DIST_11	0.4052***	0.0657
SUB_DIST_13	0.1094	0.0672
SUB_DIST_21	0.3954***	0.0683
SUB_DIST_23	-0.0921	0.0766
SUB_DIST_31	-0.3834***	0.0689
SUB_DIST_32	0.1514*	0.0913
SUB_DIST_51	-0.3209***	0.0789
FAM_SIZE	-0.0053	0.0051
TOT_ACRES_CULT	-0.0015	0.0077
_cons	0.2735*	0.1614
F (17, 358)	14.92***	
R^2	0.445	
N	373	

Note: *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

Table A-24. OLS Regression Estimates for the Proportion of Groundnut Production Area in HYRVs: (2) Project Village (PV)

Variable	Coefficient Estimate	Standard Error
PV	0.1389***	0.0427
HHH_AGE	0.0008	0.0015
HHH_MALE	0.0683	0.0684
MSTAT_MARIED	-0.0134	0.1308
MSTAT_WIDO	-0.0469	0.1336
RESP_MALE	0.0373	0.0433
EDU_PRIM	0.0648	0.0599
EDU_SEC	0.0066	0.0689
EDU_TERT	0.1361	0.0834
SUB_DIST_11	0.4046***	0.0656
SUB_DIST_13	0.1095	0.0671
SUB_DIST_21	0.3950***	0.0681
SUB_DIST_23	-0.0921	0.0765
SUB_DIST_31	-0.3840***	0.0687
SUB_DIST_32	0.1513*	0.0912
SUB_DIST_51	-0.3216***	0.0787
FAM_SIZE	-0.0053	0.0051
TOT_ACRES_CULT	-0.0015	0.0077
_cons	0.2718*	0.1610
F (18, 354)	15.97***	
R^2	0.445	
N	373	

Note: *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

Table A-25. Instrumental Variables: 1st Stage Estimates for the Intent to Treat (ITT)

Variable	Coefficient Estimate	Standard Error
HHH_AGE	0.0039**	0.0017
HHH_MALE	0.0581	0.0784
MSTAT_MARIED	0.0576	0.1501
MSTAT_WIDO	0.1153	0.1532
RESP_MALE	-0.1278***	0.0496
EDU_PRIM	-0.0091	0.0687
EDU_SEC	0.0332	0.0790
EDU_TERT	0.0602	0.0956
SUB_DIST_11	-0.0648	0.0752
SUB_DIST_13	0.0164	0.0769
SUB_DIST_21	-0.0522	0.0781
SUB_DIST_23	-0.0005	0.0877
SUB_DIST_31	-0.0690	0.0788
SUB_DIST_32	-0.0116	0.1046
SUB_DIST_51	-0.0809	0.0902
FAM_SIZE	-0.0040	0.0059
TOT_ACRES_CULT	0.0072	0.0088
PROJ_VILAGE	0.6569***	0.0490
_cons	-0.1902	0.1846
$F(17, 358)$	13.39***	
R^2	0.4051	
N	373	

Note: *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

Table A-26. Instrumental Variables: 2nd Stage Estimates for the Proportion of Groundnut Production Area in HYRVs

Variable	Coefficient Estimate	Standard Error
BEN	0.2115***	0.0668
HHH_AGE	-4.9E-06	0.0016
HHH_MALE	0.0560	0.0707
MSTAT_MARIED	-0.0256	0.1345
MSTAT_WIDO	-0.0713	0.1380
RESP_MALE	0.0643	0.0470
EDU_PRIM	0.0668	0.0615
EDU_SEC	-0.0004	0.0708
EDU_TERT	0.1234	0.0860
SUB_DIST_11	0.4183***	0.0676
SUB_DIST_13	0.1061	0.0689
SUB_DIST_21	0.4060***	0.0702
SUB_DIST_23	-0.0920	0.0785
SUB_DIST_31	-0.3695***	0.0708
SUB_DIST_32	0.1537	0.0936
SUB_DIST_51	-0.3045***	0.0812
FAM_SIZE	-0.0045	0.0053
TOT_ACRES_CULT	-0.0030	0.0079
_cons	0.3120*	0.1639
F (17, 358)	14.98***	
R^2	0.4155	
N	373	

Note: *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

Table A-27. HH Groundnut Value Addition by Group

	BEN		C_IN		C_OUT		Total	
Value Added to Gnuts	Count	%	Count	%	Count	%	Count	%
Total								
No	226	94.2	115	95.8	118	98.3	459	95.6
Yes	14	5.8	5	4.2	2	1.7	21	4.4
Kumi								
No	56	93.3	30	100.0	30	100.0	116	96.7
Yes	4	6.7	0	0.0	0	0.0	4	3.3
Pallisa								
No	58	96.7	29	96.7	29	96.7	116	96.7
Yes	2	3.3	1	3.3	1	3.3	4	3.3
Tororo								
No	56	93.3	26	86.7	29	96.7	111	92.5
Yes	4	6.7	4	13.3	1	3.3	9	7.5
Mbale								
No	26	86.7	16	100.0	14	100.0	56	93.3
Yes	4	13.3	0	0.0	0	0.0	4	6.7
Sironko								
No	30	100.0	14	100.0	16	100.0	60	100.0
Yes	0	0.0	0	0.0	0	0.0	0	0.0
Value Added Explained								
Shelling	7	50.0	5	100.0	2	100.0	14	66.7
Making peanut butter	0	0.0	0	0.0	0	0.0	0	0.0
Making flour	0	0.0	0	0.0	0	0.0	0	0.0
Roasting	0	0.0	0	0.0	0	0.0	0	0.0
Boiling	1	7.1	0	0.0	0	0.0	1	4.8
Blending	0	0.0	0	0.0	0	0.0	0	0.0
Packaging	4	28.6	0	0.0	0	0.0	4	19.0
Not applicable	2	14.3	0	0.0	0	0.0	2	9.5

Table A-28. Market Access

Problems with Market Access	BEN Count	BEN %	C_IN Count	C_IN %	C_OUT Count	C_OUT %	Total Count	Total %
Total								
No	193	80.4	108	90.0	109	90.8	410	85.4
Yes	47	19.6	12	10.0	11	9.2	70	14.6
Kumi								
No	49	81.6	28	93.3	29	96.6	106	88.3
Yes	11	18.3	2	6.6	1	3.3	14	11.6
Pallisa								
No	46	76.7	26	86.7	29	96.7	101	84.2
Yes	14	23.3	4	13.3	1	3.3	19	15.8
Tororo								
No	44	73.3	25	83.3	23	76.7	92	76.7
Yes	16	26.7	5	16.7	7	23.3	28	23.3
Mbale								
No	25	83.3	15	93.8	12	85.7	52	86.7
Yes	5	16.7	1	6.3	2	14.3	8	13.3
Sironko								
No	29	96.7	14	100.0	16	100.0	59	98.3
Yes	1	3.3	0	0.0	0	0.0	1	1.7

Market Access Explained								
Market readily available	67	36.6	36	36.7	36	44.4	139	38.4
Low prices offered	35	19.1	6	6.1	12	14.8	53	14.6
Lack of proper market	12	6.6	3	3.1	2	2.5	17	4.7
Didn’t grow gnuts	8	4.4	11	11.2	2	2.5	21	5.8
Doesn't sell gnuts	3	1.6	1	1.0	4	4.9	8	2.2

Table A-29. Groundnuts Sales Qualitative

	BEN		C_IN		C_OUT		Total	
How Groundnuts Are Sold	Count	%	Count	%	Count	%	Count	%
Group Sale	1	0.4	1	0.8	1	0.8	3	0.6
Individual Sale	130	54.2	57	47.5	62	51.7	249	51.9
Not Applicable	109	45.4	62	51.7	57	47.5	228	47.5
Who Purchased Groundnuts								
Local traders	101	42.1	48	40.0	53	44.2	202	42.1
Outside traders	26	10.8	2	1.7	6	5.0	34	7.1
NGO	0	0.0	0	0.0	0	0.0	0	0.0
Seed company	0	0.0	0	0.0	0	0.0	0	0.0
Other farmers	4	1.7	5	4.2	1	0.8	10	2.1
NAADS	0	0.0	0	0.0	0	0.0	0	0.0
Processor	0	0.0	0	0.0	0	0.0	0	0.0
Not applicable	106	44.2	63	52.5	58	48.3	227	47.3
Groundnut Sale Location								
Farm Gate	80	33.3	34	28.3	37	30.8	151	31.5
Market in Subcounty	37	15.4	22	18.3	23	19.2	82	17.1
Other Subcounty	7	2.9	0	0.0	3	2.5	10	2.1
District HQ	0	0.0	1	0.8	0	0.0	1	0.2
Outside District	2	0.8	1	0.8	0	0.0	3	0.6
Didn’t Sell	17	7.1	7	5.8	9	7.5	33	6.9
Not Applicable	100	41.7	55	45.8	48	40.0	203	42.3

Note: Group sale for BEN (1) in Kumi and for controls (2) in Pallisa.

Table A-30. Groundnut Storage

Number of Days Gnuts Stored Before Selling?	BEN		C_IN		C_OUT		Total	
	Mean	N	Mean	N	Mean	N	Mean	N
Total	97.28	133	100.38	58	114.69	62	102.26	253
Kumi	110.5	28	125.6	9	114.0	5	114.1	42
Pallisa	72.6	34	80.4	13	93.8	24	81.2	71
Tororo	83.9	33	98.2	16	92.3	13	89.3	62
Mbale	131.1	27	141.8	11	168.0	10	141.2	48
Sironko	96.7	11	57.2	9	141.0	10	99.6	30

Table A-31. Aflatoxin Awareness by HH, District, and by Group

	BEN		C_IN		C_OUT		Total	
Aflatoxin Awareness	Count	%	Count	%	Count	%	Count	%
Total								
No: “Aflatoxin”	90	37.5	53	44.2	45	37.5	188	39.2
Yes: “Aflatoxin”	150	62.5	67	55.8	75	62.5	292	60.8
No: “Rotten/Moldy”	21	23.3	12	22.6	3	6.7	36	19.1
Yes: “Rotten/Moldy”	69	76.7	41	77.4	42	93.3	152	80.9
Kumi								
No: “Aflatoxin”	18	30.0	11	36.7	17	56.7	46	38.3
Yes: “Aflatoxin”	42	70.0	19	63.3	13	43.3	74	61.7
No: “Rotten/Moldy”	6	33.3	1	9.1	1	5.9	8	17.4
Yes: “Rotten/Moldy”	12	66.7	10	90.9	16	94.1	38	82.6
Pallisa								
No: “Aflatoxin”	23	38.3	18	60.0	4	13.3	45	37.5
Yes: “Aflatoxin”	37	61.7	12	40.0	26	86.7	75	62.5
No: “Rotten/Moldy”	3	13.0	2	11.1	0	0.0	5	11.1
Yes: “Rotten/Moldy”	20	87.0	16	88.9	4	100.0	40	88.9
Tororo								
No: “Aflatoxin”	37	61.7	16	53.3	15	50.0	68	56.7
Yes: “Aflatoxin”	23	38.3	14	46.7	15	50.0	52	43.3
No: “Rotten/Moldy”	9	24.3	4	25.0	0	0.0	13	19.1
Yes: “Rotten/Moldy”	28	75.7	12	75.0	15	100.0	55	80.9
Mbale								
No: “Aflatoxin”	9	30.0	5	31.3	8	57.1	22	36.7
Yes: “Aflatoxin”	21	70.0	11	68.8	6	42.9	38	63.3
No: “Rotten/Moldy”	1	11.1	3	60.0	1	12.5	5	22.7
Yes: “Rotten/Moldy”	8	88.9	2	40.0	7	87.5	17	77.3
Sironko								
No: “Aflatoxin”	3	10.0	3	21.4	1	6.2	7	11.6
Yes: “Aflatoxin”	27	90.0	11	78.5	15	93.7	53	88.3
No: “Rotten/Moldy”	2	66.7	2	66.7	1	100.0	5	71.4
Yes: “Rotten/Moldy”	1	33.3	1	33.3	0	0.0	2	28.6

Table A-32. Aflatoxin Problems with Groundnuts

Experienced Problems With Aflatoxin	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
Total								
No	79	32.9	49	40.8	37	30.8	165	34.4
Yes	161	67.1	71	59.2	83	69.2	315	65.6
Kumi								
No	18	30.0	13	43.3	13	43.3	44	36.7
Yes	42	70.0	17	56.7	17	56.7	76	63.3
Pallisa								
No	17	28.3	13	43.3	1	3.3	31	25.9
Yes	43	71.7	17	56.7	29	96.7	89	74.2
Tororo								
No	27	45.0	14	46.7	16	53.3	57	47.5
Yes	33	55.0	16	53.3	14	46.7	63	52.5
Mbale								
No	2	6.7	3	18.7	1	7.1	6	10.0
Yes	28	93.3	13	81.2	13	92.9	54	90.0
Sironko								
No	15	50.0	6	42.9	6	37.5	27	45.0
Yes	15	50.0	8	57.1	10	62.5	33	55.0

Table A-33. Aflatoxin Contamination in the Last Five Years

Number of Cases of Aflatoxin Contamination	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
1 in Last 5 Years	63	39.1	26	36.6	35	42.2	124	39.4
2 in Last 5 Years	66	41.0	29	40.8	21	25.3	116	36.8
3 in Last 5 Years	11	6.8	6	8.5	12	14.5	29	9.2
4 in Last 5 Years	5	3.1	5	7.0	9	10.8	19	6.0
5 in Last 5 Years	16	9.9	5	7.0	6	7.2	27	8.6

Table A-34. Reporting of Aflatioxin Contamination

	BEN		C_IN		C_OUT		Total	
Aflatoxin Reporting	Count	%	Count	%	Count	%	Count	%
Total	161	100.0	71	100.0	83	100.0	315	100.0
No one	46	28.6	25	35.2	30	36.1	101	32.1
Extension agent	28	17.4	12	16.9	13	15.7	53	16.8
Researcher	2	1.2	0	11.3	1	1.2	3	1.0
My relative	14	8.7	8	0.0	8	9.6	30	9.5
My neighbor	28	17.4	15	21.1	13	15.7	56	17.8
Group members	42	26.1	11	15.5	14	16.9	67	21.3
Buyers	1	0.6	0	0.0	4	4.8	5	1.6

Table A-35. Change from Feedback on Aflatoxin Contamination

Changes because of Discussion/Feedback	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
Total	161	100.0	71	100.0	83	100.0	315	100.0
None	26	16.1	16	22.5	16	19.3	58	18.4
Choice of variety	13	8.1	7	9.9	11	13.3	31	9.8
Storage method	37	23.0	17	23.9	13	15.7	67	21.3
Time to harvest	9	5.6	5	7.0	3	3.6	17	5.4
Drying method	48	29.8	13	18.3	27	32.5	88	27.9
Selection for market	3	1.9	1	1.4	1	1.2	5	1.6
What to discard	25	15.5	12	16.9	12	14.5	49	15.6

Table A-36. Average Percentage Loss from Aflatoxin Contamination

	BEN		C_IN		C_OUT		Total	
Average Percentage Loss	Count	%	Count	%	Count	%	Count	%
Total	161	5.8	71	3.6	83	4.6	315	5.0
Kumi	42	4.2	17	4.4	17	3.3	76	4.0
Pallisa	43	7.7	17	4.5	29	5.8	89	6.5
Tororo	33	6.5	16	2.4	14	3.9	63	4.9
Mbale	28	6.0	13	3.8	13	5.9	54	5.5
Sironko	15	2.9	8	1.7	10	2.8	33	2.6

Table A-37. Removal of Aflatoxin Contaminated Groundnuts Before Storage

Aflatoxin Removal for Storage	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
Total	161	100.0	71	100.0	83	100.0	315	100.0
No	26	16.1	11	15.5	12	14.5	49	15.6
Always	87	54.0	41	57.7	56	67.5	184	58.4
Sometimes	48	29.8	19	26.8	15	18.1	82	26.0
Kumi	42	100.0	17	100.0	17	100.0	76	100.0
No	10	23.8	4	23.5	5	29.4	19	25.0
Always	25	59.5	12	70.6	11	64.7	48	63.2
Sometimes	7	16.7	1	5.9	1	5.9	9	11.8
Pallisa	43	100.0	17	100.0	29	100.0	89	100.0
No	2	4.7	0	0.0	1	3.4	3	3.4
Always	38	88.4	17	100.0	28	96.6	83	93.3
Sometimes	3	7.0	0	0.0	0	0.0	3	3.4
Tororo	33	100.0	16	100.0	14	100.0	63	100.0
No	9	27.3	4	25.0	4	28.6	17	27.0
Always	7	21.2	2	12.5	3	21.4	12	19.0
Sometimes	17	51.5	10	62.5	7	50.0	34	54.0
Mbale	28	100.0	13	100.0	13	100.0	54	100.0
No	1	3.6	2	15.4	0	0.0	3	5.6
Always	14	50.0	7	53.8	7	53.8	28	51.9
Sometimes	13	46.4	4	30.8	6	46.2	23	42.6
Sironko	15	100.0	8	100.0	10	100.0	33	100.0
No	4	26.7	1	12.5	2	20.0	7	21.2
Always	3	20.0	3	37.5	7	70.0	13	39.4
Sometimes	8	53.3	4	50.0	1	10.0	13	39.4

Table A-38. Removal of Aflatoxin Contaminated Groundnuts Before Eating

	BEN		C_IN		C_OUT		Total	
Aflatoxin Removal for Eating	Count	%	Count	%	Count	%	Count	%
Total	161	100.0	71	100.0	83	100.0	315	100.0
No	11	6.8	4	5.6	5	6.0	20	6.3
Always	129	80.1	56	78.9	68	81.9	253	80.3
Sometimes	21	13.0	11	15.5	10	12.0	42	13.3
Kumi	42	100.0	17	100.0	17	100.0	76	100.0
No	8	19.0	3	17.6	4	23.5	15	19.7
Always	29	69.0	14	82.4	12	70.6	55	72.4
Sometimes	5	11.9	0	0.0	1	5.9	6	7.9
Pallisa	43	100.0	17	100.0	29	100.0	89	100.0
No	2	4.7	0	0.0	0	0.0	2	2.2
Always	41	95.3	16	94.1	29	100.0	86	96.6
Sometimes	0	0.0	1	5.9	0	0.0	1	1.1
Tororo	33	100.0	16	100.0	14	100.0	63	100.0
No	1	3.0	1	6.3	0	0.0	2	3.2
Always	17	51.5	6	37.5	5	35.7	28	44.4
Sometimes	15	45.5	9	56.3	9	64.3	33	52.4
Mbale	0	0.0	0	0.0	0	0.0	0	0.0
No	27	96.4	12	92.3	13	100.0	52	96.3
Always	1	3.6	1	7.7	0	0.0	2	3.7
Sometimes	28	100.0	13	100.0	13	100.0	54	100.0
Sironko	15	100.0	8	100.0	10	100.0	33	100.0
No	0	0.0	0	0.0	1	10.0	1	3.0
Always	15	100.0	8	100.0	9	90.0	32	97.0
Sometimes	0	0.0	0	0.0	0	0.0	0	0.0

Table A-39. Removal of Aflatoxin Contaminated Groundnuts Before Selling

	BEN		C_IN		C_OUT		Total	
Aflatoxin Removal for Sale	Count	%	Count	%	Count	%	Count	%
Total	161	100.0	71	100.0	83	100.0	315	100.0
No	45	28.0	23	32.4	28	33.7	96	30.5
Always	66	41.0	15	21.1	25	30.1	106	33.7
Sometimes	50	31.1	33	46.5	30	36.1	113	35.9
Kumi	42	100.0	17	100.0	17	100.0	76	100.0
No	19	45.2	12	70.6	12	70.6	43	56.6
Always	19	45.2	2	11.8	4	23.5	25	32.9
Sometimes	4	9.5	3	17.6	1	5.9	8	10.5
Pallisa	43	100.0	17	100.0	29	100.0	89	100.0
No	8	18.6	3	17.6	8	27.6	19	21.3
Always	30	69.8	8	47.1	20	69.0	58	65.2
Sometimes	5	11.6	6	35.3	1	3.4	12	13.5
Tororo	33	100.0	16	100.0	14	100.0	63	100.0
No	4	12.1	3	18.8	1	7.1	8	12.7
Always	7	21.2	2	12.5	0	0.0	9	14.3
Sometimes	22	66.7	11	68.8	13	92.9	46	73.0
Mbale	28	100.0	13	100.0	13	100.0	54	100.0
No	0	0.0	1	7.7	0	0.0	1	1.9
Always	10	35.7	3	23.1	0	0.0	13	24.1
Sometimes	18	64.3	9	69.2	13	100.0	40	74.1
Sironko	15	100.0	8	100.0	10	100.0	33	100.0
No	14	93.3	4	50.0	7	70.0	25	75.8
Always	0	0.0	0	0.0	1	10.0	1	3.0
Sometimes	1	6.7	4	50.0	2	20.0	7	21.2

Table A-40. Do Buyers Prefer Aflatoxin-Free Groundnuts

	BEN		C_IN		C_OUT		Total	
Buyers Preference	Count	%	Count	%	Count	%	Count	%
Total	161	100.0	71	100.0	83	100.0	315	100.0
No	45	28.0	25	35.2	43	51.8	113	35.9
Always	97	60.2	35	49.3	38	45.8	170	54.0
Sometimes	19	11.8	11	15.5	2	2.4	32	10.2
Kumi	42	100.0	17	100.0	17	100.0	76	100.0
No	17	40.5	10	58.8	11	64.7	38	50.0
Always	17	40.5	5	29.4	5	29.4	27	35.5
Sometimes	8	19.0	2	11.8	1	5.9	11	14.5
Pallisa	43	100.0	17	100.0	29	100.0	89	100.0
No	18	41.9	10	58.8	22	75.9	50	56.2
Always	25	58.1	7	41.2	7	24.1	39	43.8
Sometimes	0	0.0	0	0.0	0	0.0	0	0.0
Tororo	33	100.0	16	100.0	14	100.0	63	100.0
No	1	3.0	1	6.3	0	0.0	2	3.2
Always	31	93.9	14	87.5	14	100.0	59	93.7
Sometimes	1	3.0	1	6.3	0	0.0	2	3.2
Mbale	28	100.0	13	100.0	13	100.0	54	100.0
No	1	3.6	0	0.0	0	0.0	1	1.9
Always	24	85.7	9	69.2	12	92.3	45	83.3
Sometimes	3	10.7	4	30.8	1	7.7	8	14.8
Sironko	15	100.0	8	100.0	10	100.0	33	100.0
No	8	53.3	4	50.0	10	100.0	22	66.7
Always	0	0.0	0	0.0	0	0.0	0	0.0
Sometimes	7	46.7	4	50.0	0	0.0	11	33.3

Table A-41. Use and Disposal of Aflatoxin Infested Groundnuts

	BEN		C_IN		C_OUT		Total	
Use/Method of Disposal	Count	%	Count	%	Count	%	Count	%
Total								
Feed to animals	59	36.6	25	35.2	29	34.9	113	35.9
Throw away	81	50.3	39	54.9	51	61.4	171	54.3
Burn/Bury	8	5.0	3	4.2	2	2.4	13	4.1
Consume at home	8	5.0	1	1.4	0	0.0	9	2.9
Sell it	1	0.6	0	0.0	0	0.0	1	0.3
Others	4	2.5	3	4.2	1	1.2	8	2.5

Table A-42. Most Important Causes of Aflatoxin as Perceived by Farmers

	BEN		C_IN		C_OUT		Total	
Perceived Cause	Count	%	Count	%	Count	%	Count	%
Most Important Cause	161	100.0	71	100.0	83	100.0	315	100.0
Don't know	12	7.5	10	14.1	10	12.0	32	10.2
Drought	3	1.9	1	1.4	3	3.6	7	2.2
Poor drying	99	61.5	38	53.5	47	56.6	184	58.4
Too much rain	32	19.9	17	23.9	10	12.0	59	18.7
Pests and disease	11	6.8	2	2.8	12	14.5	25	7.9
Damage/injury	2	1.2	1	1.4	0	0.0	3	1.0
Poor storage	2	1.2	2	2.8	1	1.2	5	1.6
2nd Most Important Cause	161	100.0	71	100.0	83	100.0	315	100.0
Don't know	16	9.9	8	11.3	15	18.1	39	12.4
Drought	3	1.9	1	1.4	1	1.2	5	1.6
Poor drying	19	11.8	13	18.3	5	6.0	37	11.7
Too much rain	40	24.8	18	25.4	26	31.3	84	26.7
Pests and disease	6	3.7	4	5.6	4	4.8	14	4.4
Damage/injury	16	9.9	3	4.2	4	4.8	23	7.3
Poor storage	61	37.9	24	33.8	28	33.7	113	35.9

Table A-43. Primary Method of Drying Groundnut: Overall and by Region

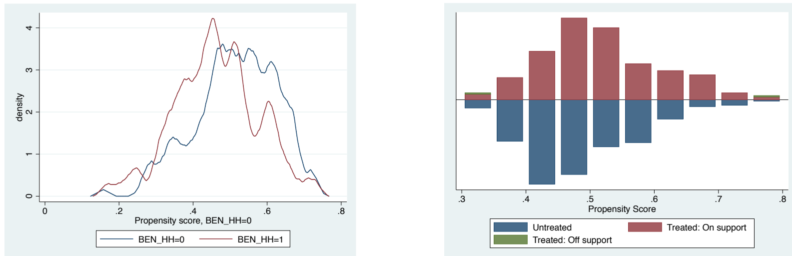
	BEN		C_IN		C_OUT		Total	
	Count	%	Count	%	Count	%	Count	%
Primary drying method								
Pavement	23	9.6	11	9.2	16	13.3	50	10.4
Open Earth at Home	181	75.4	92	76.7	86	71.7	359	74.8
Tarpaulin	10	4.2	0	0.0	3	2.5	13	2.7
Others	26	10.8	17	14.2	15	12.5	58	12.1
Drying method by District								
Kumi								
Pavement	1	1.7	0	0.0	0	0.0	1	0.8
Open Earth at Home	51	85.0	26	86.7	26	86.7	103	85.8
Tarpaulin	4	6.7	0	0.0	1	3.3	5	4.2
Others	4	6.7	4	13.3	3	10.0	11	9.2
Pallisa								
Open Earth at Home	58	96.7	30	100.0	29	96.7	117	97.5
Others	2	3.3	0	0.0	1	3.3	3	2.5
Tororo								
Pavement	1	1.7	1	3.3	3	10.0	5	4.2
Open Earth at Home	39	65.0	20	66.7	16	53.3	75	62.5
Tarpaulin	5	8.3	0	0.0	1	3.3	6	5.0
Others	15	25.0	9	30.0	10	33.3	34	28.3
Mbale								
Pavement	21	70.0	10	62.5	13	92.9	44	73.3
Open Earth at Home	6	20.0	3	18.8	0	0.0	9	15.0
Tarpaulin	1	3.3	0	0.0	0	0.0	1	1.7
Others	2	6.7	3	18.8	1	7.1	6	10.0
Sironko								
Open Earth at Home	27	90.0	13	92.9	15	93.8	55	91.7
Tarpaulin	0	0.0	0	0.0	1	6.3	1	1.7
Others	3	10.0	1	7.1	0	0.0	4	6.7

Note: Field drying included under others.

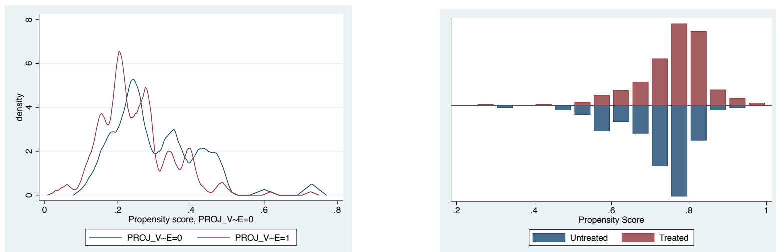
Figure 1-A. Map of Districts in Uganda

Source: Mwebaze (2002)

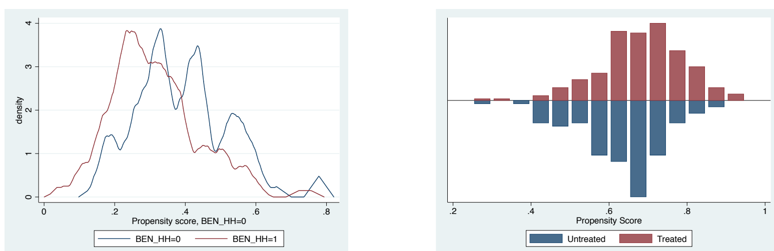
Figure 2-A. Common Support for PSM Specifications (1)-(5)



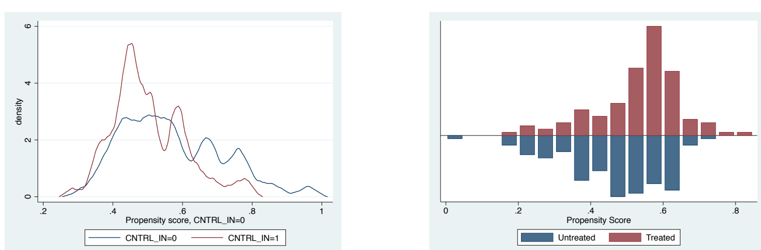
PSM(1): BEN vs. C_ALL



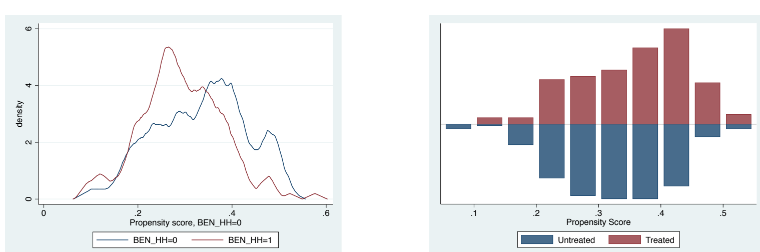
PSM(2): BEN vs. C_IN



PSM(3): C_IN vs. C_OUT



PSM(4): PV vs. C_OUT



PSM(5): BEN vs. C_OUT

Appendix B. ATU 2014 Survey Instrument

Name of Respondent from ATU Survey:______________________ HH ID#__________________

Enumerator Name/ID #:____

GROUNDNUT IMPACT ASSESSMENT/ENDLINE

A. HOUSEHOLD AND SOCIO-ECONOMIC CHARACTERISTICS

1. Name of Head of Household (HHH): ______________________________

2. Sex of HHH:_____ (1=M 2=F)

3. District:______ (1=Kumi, 2=Pallisa, 3=Tororo, 4=Mbale, 5= Sironko)

4. Sub-county:_____ (11=Kidongole, 12=Nyero, 21=Lyama, 22=Kasodo, 31=Nagongera, 32=Kachonga, 41=Butiru, 51=Bukhalu)

5. Age of HHH (years): _______

6. Formal education of HHH(highest level attained): __________________________ (1= Illiterate/no formal schooling, 2= Primary, 3= Secondary [A or O level],4= Tertiary anything beyond S4 / higher TTC)

7. Marital status of HHH: _________________
(1= Single, 2= Married, 3= Widowed, 4= Divorced/Separated)

8. Household composition (**please indicate the number of individuals for each category of household members – Note:** ***each person should be counted only once.*****)**

Age group	Total number in age group	Participating in farm activities all the time		Not directly participating in farm activities	
		Male	**Female**	**Male**	**Female**
Above 60 yrs					
18 -60 years					
12 - 17 years					
11 or less					

9. Were you a member of a farmer or ATU group(s)? ______
(0=No, 1=Yes; *if yes, please specify organization and membership dates*:

____

10. Please list your main sources of household income in order of importance. (i.e. farming, trade, employment, etc.)

Rank	Main source of income 2013
1	
2	
3	
4	
5	

11. How has the income coming from crop production changed since 2004?__________
(1= Increased, 2= Decreased, 3= Stayed the same?)

12. What total area of land did you cultivate in year 2013 season A (acres)? ___________

13. List five crops in terms of area cultivated now:

List Crops in order of area planted	**Year 2013 (season A)**	
	Crop	**Acres Planted**
Largest		
Smallest		

14. Rank the main cash crops in order of contribution to household income. (1 is the most and 9 is the least, add crops as applicable)

Cash Crop	**Rank in 2013 (season A).**
Cassava	
G.nuts	
Legumes (Green Grams cow peas / beans)	
Sweet potato	
Maize	
Sorghum	
Millet	
Cotton	
Rice	

15. Think about the main foods that you consume as sauce, how frequent did the following sauces feature in your diet in 2013? Please indicate in days per week:1= high (almost every day), 2=medium (1-2 per week),3=low for (rarely 1/month), 4=never

Main Sauces	**Frequency in 2013**
Meat (without g.nuts)	
Chicken (without g.nuts)	
Fish (without g.nuts)	
Cowpeas (without g.nuts)	
Beans (without g.nuts)	
Green grams (without g.nuts)	
Greens (without g.nuts)	
Groundnuts alone (binyewa)	
Gnuts in combination with greens, legumes or meat	

16. How has your standard of living changed since 2004? ________
(1= Increased,2= Decreased, 3= Stayed the same)

17. Below is a picture of a 10-step ladder. Imagine that at the bottom, on the first step, stand the poorest people, and on the highest step, the tenth, stand the richest.

17a. On which step of this ladder is your household located today? ______________

17b. On which step of the ladder was your household in 2004? _______________

18. What are the two main reasons for the change?

____

B. GROUNDNUT PRODUCTION

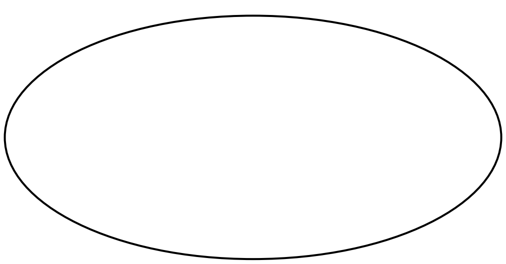
19. Does the HH grow groundnuts (verify from Question 13)? _____(_____ acres). (0= No 1= Yes)
IF NO SKIP TO Q. 24

20. If 19 is **YES,** who in the HH grows the groundnuts _______ (Indicate all that apply: 1=Male HHH, 2=Adult Female/Female HHH, 3= Male Youth, 4= Female Youth).

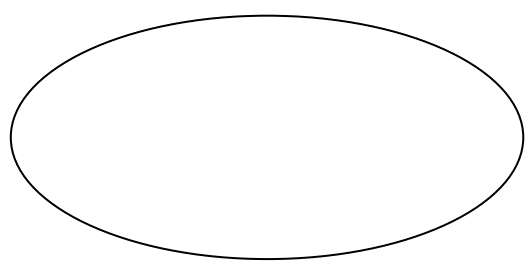
21. How has the household's groundnut production area changed since 2004? __________
(1= Increased, 2= Decreased,3= Stayed the same?)

22. Using proportional piling:
Enumerator: Put 20 beans in the circle to represent area of gnut production in 2013.
Let the household put as many beans in the circle for 2004 as they wish (in 22a), then separate the total number of beans from 22a by variety (in 22b).

22a. Record number of beans used to represent 2004 production. _____________



2013 Gnut Production Area



2004 Gnut Production Area

22b. Approximately how much of each variety was planted in 2004?

Variety	Red Beauty	Igola 1	Serenut						Erudurudu Red	Others (specify)
			1	2	3	4	5	6		
Place beans from 2004 (22a) into variety columns										
Total # of Beans										

HH ID#__________________

23. If **YES to 19**, what Groundnut seed did you grow in 2013? **(Pictures or samples will be used to help farmers identify varieties.)**

Variety	2013 (Season A)						Question 57 Wait to ask this question
	Yes/ No	Source of seed	Cost of seed per unit.	Qty planted	Acres Planted	Qty harvested	Aflatoxin ranking 1=highest
1. Red Beauty							
2. Igola 1							
3. Serenut 1							
4. Serenut 2							
5. Serenut 3							
6. Serenut 4							
7. Serenut 5							
8 Serenut 6							
9 Erudurudu Red							
10 Others [specify]							
Units of measurement	**Seed? ________________ Conversion to kg: 1 unit -______ kg** **Quantity Harvested? ______________ Conversion to kg: 1 unit -______ kg**						

***Codes for Unit of measurement**: 1= kg, 2= basin, 3= bag unshelled, 4= bag shelled*

***Codes for source of seed**: 0= N/A, 1= Research/Serere, 2= NAADS, 3= Bought from a stockiest, 4= VECO, 5= Own home saved seed, 6= Bought from multiplication farmers, 7= Bought from the open market, 8= Self Help Uganda, 9= DFA/Farmers Association, 10= FAO, 11= Seed company 12; Other specify ______________________________ (e.g given by by other farmer or relative)*

24. If you do not grow Groundnuts, WHY NOT?

____

____

25. For each variety grown above (from 23) indicate on the table below why you like or dislike it, and give ranks (1= best liked and 9 is least liked.) start by filling columns for likes and dislikes, then rank after.

Variety	What do you like about the variety (likes)	What don't you like about the variety (dislikes)	Rank the varieties according to preference	Main Reason for the ranking
1. Red Beauty				
2. Igola 1				
3. Serenut 1				
4. Serenut 2				
5. Serenut 3				
6. Serenut 4				
7. Serenut 5				
8 Serenut 6				
9 Erudurudu red				
10 Others [specify]				

<u>Code for likes</u>: *0=don't know the variety,1= High yielding, 2= Rossette resistant, 3= Tolerate drought, 4= Good taste, 5= Matures early, 6= Marketable, 7= Good price, 8= Ease of harvesting, 9= Color, 10= Others (please specify)*

<u>Code for dislikes</u>: *0=don't know the variety,1= Low yield, 2= Not rossette resistant, 3= Not tolerant to drought, 4= Poor taste, 5= Late maturing, 6= Low market, 7= Low price, 8= Too labour intensive, 9= Too much weeding, 10= Difficult to shell, 11= Remains in the soil when uprooting, 12= Changes color when harvested late, 13= Poor germination/dormancy, 14= Others (please specify)*

26. If you planted home saved seed, how long have you been keeping and replanting the seed? (please indicate by variety):

Variety: ___________, # of years: _____; Variety: ___________, # of years: _____; Variety: ___________, # of years: _____;

Variety: ___________, # of years: _____; Variety: ___________, # of years: _____; Variety: ___________, # of years: _____.

27. Training in groundnut production and seed multiplication:

Type of Training	No	Yes before end of 2004	Training Provided by: (use codes from question above)	Yes during 2005 to 2012	Training Provided by: (use codes from question above)	Yes in 2013	Training Provided by: (use codes from question above)
Received training in Gnut production							
Received training in Gnut multiplication							

***Code for Training Agency**: 0= N/A, 1= NAADS, 2= Serere, 3= VECO, 4= Self Help Africa, 5= AT Uganda, 6= Farmer's Association, 7= Makerere, 8= Other (please specify) ____________________________.*

28. Have you ever multiplied Groundnuts for a Seed company or an NGO? ________ (0= No 1= Yes)

29. If so, when?

Season _________ Year______Area_______ Qty produced_______ Company/Org___________________________

Season _________ Year______Area_______ Qty produced_______ Company/Org___________________________

Season _________ Year______Area_______ Qty produced_______ Company/Org___________________________

Season _________ Year______Area_______ Qty produced_______ Company/Org___________________________

Season _________ Year______Area_______ Qty produced_______ Company/Org___________________________

30. Have you heard of any new groundnut varieties in the last three years? _____ (0= No 1=Yes).

31. If Yes to 30, where did you hear about the new varieties?(please indicate all that apply) ________________________________ (0= N/A,1= NAADS, 2= Serere/NARO, 3= VECO, 4= Self Help Africa, 5= Other NGO, 6= Farmer's Association, 7= Makerere, 8= Other farmers, 9= Radio, 10= Jinja Show, 11= Other (please specify) ____).

32. Are the new groundnut varieties readily available?______ (0= No 1= Yes)

33. If Yes to 32, where are the new gnut varieties available to obtain or purchase? (Please indicate all that apply) ____________________ (0= N/A, 1= Serere,2= Market, 3= Stockist,4= NGO,5= NAADS, 6= Other (please specify) __________________________).

34. Use of Improved/Recommended groundnut production practices (do rating before asking reason for modification or why practice is not followed)

Practice/Principle Recommended	**Notes on recommended practice**	**Rating**	**What is being done? (Ask if not fully followed or followed with modification)**	**Why? (Reason for modification or for not following) Open ended question**
1. Site selection	Free draining soil not after legume			
2. Land preparation	Weed free, fine seed bed			
3. Timely planting	At the onset of rains, after a heavy rain			
4. Spacing	45x10cm for bunch types e.g. Serenut 3 & 4, 45x15cm for Serenut 2			
5. Improved variety	E.g. Serenut 1, 2, 3, 4, Igola1 & Red beauty			
6. Weed control	Keep garden weed free; at or after flowering do hand weeding			
7. Pest control	Spray against pests. Leaf miner			
8. Fertilizer use	Use SSP at planting 50kg/acre or use manure or rhizobia			
9. Timely harvest	Dark markings on inside of shell I.e. at maturity			
10. Proper drying	Cracks on biting or rattle on shaking or during drying don't keep indoors for more than a day without drying			
11. Proper storage	Cool, dry place, aerated containers, off the ground			

1= Fully followed, 2= Not fully followed, 3 not followed at all.

35. GNUT production labour details for 2013 (Season A)

Activity		**Family labour**		**Group Labour**		**Hired Labour**		**Total Labourcost (incl. food)**	**Wage Rate for Hired Labour by activity**
	Method 1=hand, 2=animal 3=mechanized/ tractor	**# of people**	**Days**	**# of people**	**Days**	**# of people**	**Days**	**Shillings**	**Shillings/day**
	a.	b.	c.	h.	i.	k.	l.	m.	
1. Land preparation									
2. Sowing/Planting									
3. Watering *									
4. Fertilizer application									
5. Herbicide application									
6. Other chemical spraying									
7. Weeding 1st									
8. Weeding 2nd									
9. Harvesting									
10. Threshing/shelling									
11. Drying									
12. Transport (field to home)									
13. Other specify:									

NOTE: If the task is done by animal traction or tractor, the cost includes the cost of hiring the equipment.

Additional Notes:

36. Other GNUT production cost details:

Cost Item	2013 (Season A)		
	Unit	**Quantity**	**Price**
Insecticide			
Herbicide			
Fertilizer			
Sprayer			
Bags			

37. What major challenges have you faced with groundnut production?

____

____

38.What are you doing differently as a result of these challenges?

____

____

C. INCOME

39. Which family member makes decision about the use of the money from Groundnut sales? ______(0= N/A, 1= male head of household, 2= female head of household, 3= both man and woman, 4= other, please specify ___________________________)

40. Where did you go to sell the G.nuts? ______in 2013 (0= N/A, 1= Farm Gate, 2= Market in subcounty, 3= Other subcounty, 4= District HQ, 5= Outside district, 6= Didn't sell).

41. How long did you store before selling?(days) _______in 2013

42. What quantity did you sell? (Specify units) _______in 2013

43. At what price did you sell it (per bag/ basin/ kg **circle unit)** in 2013 __________

44. How did you sell it? ______ (0= N/A, 1= as a group, 2=as an individual)

45. Who did you sell it to? _______ (0= N/A, 1= Local Traders, 2= Traders coming from outside, 3= NGO ______________, 4= Seed Company, 5= Other Farmers,6= NAADS,7= Processor)

46. Did you experience any problems with access to Market? _______ (0= No 1= Yes)

47. Please explain: ____

48. Do you undertake any activities to add value to your groundnuts before selling? _______ (0= No 1= Yes)

49. If so, what activities? (*pleaseindicate all that apply*)___________________________ (0= N/A, 1= Shelling, 2= Making peanut butter, 3= Making Flour, 4= Roasting, 5= Boiling, 6= Blending, 7= Packaging, 8= Other (please specify) _______________________________)

D. AFLATOXIN.

50. Ever heard of AFLATOXIN? _____ (0 = No, 1=Yes). If **YES go to 52**. If **NO go to 51**.

51. If No in **50** describe AFLATOXIN as *"Rotten nuts, moldy, bitter taste"* and ask again if the farmer has ever heard of this problem: _________ (No=0 Yes=1).

52. If YES in 50 or 51 above, then from whom **(Rank 2*):*** __________ (0= N/A,1= NAADS, 2= Serere/NARO, 3= VECO, 4= Self Help Africa, 5= Other NGO, 6= Farmer's Association, 7= Makerere, 8= Other farmers, 9= Radio, 10= Jinja Show, 11= Other (please specify) ____).

53. Ever experienced AFLATOXIN problem in your groundnuts? __________ (No=0 Yes=1) **(Note: Ask this to all)** If**NO** go to **65.**

54. If Yes in 53**,** thenhow often have you experienced AFLATOXIN problem in the last 5 years *you have grown groundnut*:_____ (*1 = 1/5; 2 = 2/5; 3 = 3/5; 4 = 4/5; 5 = 5/5)*

55. If Yes in 53**,** then whom did you discuss the Aflatoxin problem with? ______________(0 = No one, 1 = Extension agent; 2 = Researcher; 3 = My relative; 4 = My neighbor; 5 = Group members; 6 = Buyers; 7 = Stockist; 8 = Medical Personnel; 9 = Other, Specify _____________________________).

56. If Yes in 53**,** did the information influence your decision on groundnut production and marketing? ____________ (0 = No; 1 = Choice of variety to plant; 2 = Time to harvest; 3 = Storage method; 4 = Drying method; 5 = Selection for market; 6 = What to consume/discard; 7 = Other, Specify ____).

57. If Yes in 53**,** Variety most affected by AFLATOXIN (Rank 1, 2, 3, where 1 is most affected *(Enumerator, go back to 23 table and fill in the aflatoxin ranking at this point.).*

58. Causes of AFLATOXIN (Rank 2:from among the list below.)
Most important cause:___________________.

Second most important cause: __________________

(*0 = Don't know;1= Drought; 2 = Poor drying; 3 = Too much rain; 4 = Pests & diseases; 5 = Damage/injury; 6 = Poor Storage; 7 = Other, specify ______________.)*

59. Average percentage affected (loss) by AFLATOXIN from your: 2013(A) harvest:____ %

60. Do you remove AFLATOXIN infested grain before storing? _____(0 = No; 1 = Always; 2 = Sometimes)

61. Do you remove AFLATOXIN infested grain before eating? _____(0 = No; 1 = Always; 2 = Sometimes)

62. Do you remove AFLATOXIN infested grain before selling? _____(0 = No; 1 = Always; 2 = Sometimes)

63. Do buyers prefer AFLATOXIN free groundnuts? ____________(0 = No; 1 = Always; 2 = Sometimes)

64. What do you do with the AFLATOXIN infested grains (Indicate Top 3): ____________ (*1 = Feed to animals; 2 = Throw away; 3 = Burn/bury; 4 = Consume at home; 5 = Sell it; 6 =Other, specify____).*

65. Do you sprinkle your groundnut pods with water before shelling? ____(0 = No; 1 = Always; 2 = Sometimes)

66. If **65** is *Always or Sometimes*, what is the reason you water (Indicate top 3)? _________ *(1 = Hard Shell; 2 = Increase weight; 3 = Avoid breakage;4 = Condition imposed by Sheller; 5 = Reduce dust; 6 = Other, specify ___________________________).*

67. Method of drying In Shell groundnut (Select top 2)*: _______________ (1 = Pavement; 2 = Open earth at home; 3 = Tarpaulin; 4 = Field drying; 5 = Raised platform; 6 = Other, specify*
____

ADDITIONAL ENUMERATOR NOTES: