# Production and Consumption Traits and the Adoption of Improved Maize Varieties: Evidence from Seed Sample Packs and Cooking Demonstrations

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**Abstract**

In developing countries, semi-subsistence farmers typically assume dual roles as both consumers and producers of the same crops, which shape their adoption decisions as they balance household food security with market-driven incentives. This study, conducted in eastern Uganda, employs a field experiment with two intervention arms to assess the relative importance of these factors in farmers' decisions to adopt improved maize seed varieties. The first intervention focuses on production traits, distributing free sample packs of an improved hybrid maize variety to showcase benefits such as higher yields, pest resistance, and drought tolerance. The second intervention emphasizes consumption traits, offering cooking demonstrations and blind taste tests using flour from the same improved maize variety to highlight its taste, texture, and ease of preparation. Our findings reveal that while seed sample packs positively influenced farmers' perceptions of both production and consumption traits, cooking demonstrations primarily affected perceptions of consumption qualities. We find some evidence that the cooking demonstrations and tasting sessions significantly boosted adoption of the improved maize seed variety promoted by the intervention. However, farmers who received seed sample packs tended to recycle the harvested grain as seed in subsequent

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seasons, thereby crowding out fresh seed purchases. This practice led to productivity losses, suggesting that the seed trial packs did not translate into lasting improvements in food security or increased market participation.

Keywords: technology adoption, consumption and production traits, sample packs, cooking demonstration and blind tasting, maize, Uganda.

JEL: Q16, H24, O33, D91

# 1 Introduction

To sustainably feed a growing global population while addressing climate change and preserving biodiversity, it is essential to produce more food using less land (Tilman et al., 2011). Green Revolution technologies, particularly the development of improved varieties, have been key to achieving higher yields and enhancing resilience to environmental challenges like drought (Evenson and Gollin, 2003). Traditionally, breeding programs, including those which primarily serve smallholder farmers, have primarily focused on improving production-related traits such as yield, drought tolerance, disease resistance, and pest resistance. However, as farmers in sub-Saharan Africa often produce for self-consumption (Carletto, Corral, and Guelfi, 2017; Bellon et al., 2020), the adoption of new crop varieties is also influenced by consumer-oriented traits such as taste, color, texture, and ease of cooking. Integrating improvements in consumption-oriented attributes alongside production advantages may be crucial for driving demand for improved crop varieties.

Because the production and consumption attributes of new varieties are not directly observable to farmers upon seed purchase, widespread adoption also may require raising farmers' awareness of their beneficial attributes. A common strategy to encourage farmers to learn about a new variety is through the distribution of seed sample packs (often referred to as "trial packs", "starter packs", or "mini-kits") (Blackie and Mann, 2005; Cromwell, 1990). These seed sample packs typically contain small quantities of seed (e.g., 1 kg) and are provided for free, allowing farmers to test them on a small portion of their plot.[1] The goal is to reduce the cost and risk associated with learning about the production attributes of the variety, such that farmers will purchase the seed in subsequent seasons if they find doing so beneficial. While seed sample packs may also enable farmers to discover consumption traits after they harvest the grain obtained from the seed sample pack—such learning is often not the primary focus of this strategy—and may occur only if farmers taste the grain from the sample pack before mixing it with other varieties and/or selling it.

Strategies that explicitly aim to raise potential users' awareness about varieties' consumption-related traits are less common. This is perhaps surprising given the theoretical and empirical literature showing that in smallholder agriculture settings consumption and production decisions are inseparable (Singh,

[1] Some trials may also include small quantities of other relevant inputs such as fertilizer, pesticide, and/or herbicide. For instance, Malawi's starter pack program provided both seeds and fertilizer (Blackie and Mann, 2005).

Squire, and Strauss, 1986; LaFave and Thomas, 2016). Moreover, interventions that familiarize farmers with consumption traits, such as cooking demonstrations and tasting events, typically only focus on disclosing nutrition-related attributes (Reicks, Kocher, and Reeder, 2018).

In this paper, we test to what extent interventions that highlight production and consumption attributes of improved maize varieties to farmers, in their dual roles as both producers and consumers, can accelerate varietal turnover. To achieve this, we conduct a field experiment to test the relative effectiveness of two interventions using a cluster randomized control trial with a simple factorial design. The first intervention targets production traits by providing farmers with 1 kg sample packs with seed of an improved variety.[2] Orthogonal to this intervention, a second intervention was introduced that involves cooking demonstrations and blind tasting tests. This intervention allows farmers to familiarize themselves with consumption attributes of maize flour derived from the grain grown using improved varieties. Additionally, farmers in this treatment are provided with maize flour samples derived from the grain grown using improved varieties to further explore consumption traits at home and potentially convince other household members.

The field experiment was conducted in four districts in eastern Uganda among a representative sample of about 1,500 farmers. The area, commonly know as the Busoga Kingdom, is populated with smallholder farmers who produce for both home consumption and the market. The variety we promoted in this study is a hybrid variety familiarly called *Bazooka* (UH 5354), which, despite being widely available from agrodealers, was relatively new and thus not widely adopted by farmers. *Bazooka*'s primary notable production trait is its yield potential, which is over double that of popular open-pollinated varieties such as Longe 5 (Semalulu et al., 2022), but in terms of consumption attributes, *Bazooka* also combines a high starch content with mild sweetness. The study ran over two consecutive agricultural seasons in 2023, with endline data collected in early 2024 after the harvest of the second season.

We find that farmers who received a free seed sample pack are actually *less likely* to plant fresh seed of an improved variety in the next season because they instead use recycled seed obtained from the trial pack's harvest. Hybrid seeds are not intended to be recycled given the associated yield penalty for doing so, and hence we categorize use of recycled hybrid seed as non-adoption in our analysis. However, we find suggestive evidence that the cooking demonstration and tasting session increased the adoption of fresh *Bazooka* specifically.[3] Finally, we see little evidence that receiving both treatments had additional impacts beyond those of the same treatment—this may have been the case if, for in-

[2] We use the term "improved variety" throughout this paper to refer to both maize hybrids and open-pollinated varieties marketed and sold in our study areas, as opposed to farmer-saved seed or seed obtained through farmer-to-farmer exchanges which, in the specific context of maize, may be less effective due to cross pollination and genetic drift over multiple generations, or due to poor seed storage and handling between seasons.

[3] We deem this evidence as suggestive because while false discovery rate corrected q-values indicate significant effects, we prespecified analysis based on indices that combine outcomes over multiple similar measures, over which we do not find significant effects.

stance, some household members are more sensitive to production traits and others are more sensitive to consumption traits, and the trial pack facilitated coordination—though the estimates are fairly noisy.

Consequently, we find that while the trial pack treatment had no effect on total production or yields, there is some indication that tasting session treatment increased yields. Additionally, we did not find that increased attention to consumption traits increased the role of women in the decision-making process with respect to seed choice, as we initially expected. Moreover, we do not find effects further down the impact pathway of either intervention in terms of food security or welfare.

Exploring some of the impact pathways, we do find that the cooking demonstration and blind tasting increased the share of farmers who rank improved varieties higher on a range of consumption attributes such as taste, portions, appearance, and ease of cooking. However, we find that farmers who received the seed sample pack rank improved varieties higher in terms of production-related attributes such as yield, abiotic and biotic stress resistance, time to maturity, and germination rate, which is in line with the theory of change. Interestingly, the seed sample pack also positively affects how farmers think about consumption traits of improved varieties, suggesting farmers consume the harvest from the seed sample pack and pay close attention to consumption attributes.

Our work contributes to various strands of literature on adoption of agricultural technologies. First, we add to the limited set of experimental impact evaluations of effectiveness of trial packs in accelerating technology adoption, which finds mixed results. For instance, Emerick et al. (2016) distribute starter kits for seed of a new rice variety in India and find that seventy-six percent of treatment farmers cultivated the technology in the second season following distribution. On the other hand, Biedny et al. (2020) find that, in Tanzania, adding sample packs to demonstration plots within the framework of village-based agricultural advisors had no significant impacts on sales, orders received, or learning outcomes. Similarly, Jones et al. (2022) find provision of a horticulture mini-kit to farmers in Rwanda has no significant impact on the adoption of horticulture. While other studies with interventions featuring a trial pack exist, the aim of many is not to evaluate its impacts on future technology adoption. For instance, Boucher et al. (2024) provide a trial pack of drought tolerant varieties to farmers before offering households the opportunity to purchase the variety bundled with index insurance in the subsequent season. Morgan, Mason, and Maredia (2020) examine different extension approaches, including the use of sample packs in the southern highlands of Tanzania, and find that bean farmers' willingness to pay for the new variety is not influenced by seed sample packs, yet they do not look at actual planting decisions. We contribute to this literature by assessing the effect of seed trial packs on subsequent adoption, instead of limiting observation to a single season, and primarily investigating the immediate use of the seed sample pack. Moreover, we measure subsequent adoption using observed (revealed preference) choices, as opposed to asking farmers about their intention to use the seed in the next season, which can be prone to social desirability bias.

We also contribute to the literature on consumer acceptance of improved varieties, by introducing an intervention that exposes farmers to a variety's consumption traits. While many studies use consumer tasting of new varieties as part of the research, in order to either assess consumer preferences for the varieties or sensitize consumers to varietal traits before eliciting willingness to pay (Birol et al., 2015), these studies do not treat the tasting experience as an intervention designed to induce take-up of new varieties. As such, the opportunity to sample the new variety is not randomized between participants. Existing interventions that expose farmers to consumption attributes of new varieties mostly promote nutritional traits and rarely measure subsequent adoption in the following season (eg. Olney et al., 2015). One exception is De Brauw et al. (2018), who study the impact of the HarvestPlus' Reaching End Users project (which includes a demand creation component that focuses on consumption attributes) on the adoption of bio-fortified sweet potato in Mozambique and Uganda. They find that the combination of the demand creation treatment and production-focused extension activities increases adoption of vitamin A fortified orange-fleshed sweet potatoes in the subsequent season by over 60 percent in both Mozambique and Uganda. We contribute to this literature by developing and testing an intervention that highlights non-nutrition-related consumption traits as well as offering this both apart from and in combination with other interventions highlighting production attributes.

The rest of the paper is organized as follows. Section 2 presents research methods, including the experimental and inference designs. Section 3 describes the data study context. Section 4 presents the findings, both on our primary outcome of adoption as well as on secondary outcomes related to household decision-making, food security, and well-being. Section 5 explores potential mechanisms explaining our results, including analysis regarding participants' decisions to recycle seeds. Section 6 concludes.

# 2 Methods

## 2.1 Experimental Design

We use a field experiment to evaluate the effectiveness of two interventions, which we elaborate on in the subsequent section. The experiment takes the form of a cluster randomized control trial (RCT) structured as a 2x2 factorial design. Each factor includes both a control and a treatment level, with interventions clustered at the village level. Treatment assignment is conducted at the village level to mitigate potential concerns about spillover effects. Within each village, 10 households were randomly selected to participate in the study.

The first factor in the factorial design pertains to the seed sample pack treatment. Sampled farmers in the treatment villages received a complimentary sample of a recently introduced hybrid maize variety (*Bazooka*), whereas those in the control villages did not receive this free sample pack.

The second factor involves a cooking demonstration and tasting session. In the treatment villages, sampled farmers were invited to participate in a maize flour tasting session. Additionally, all participants in this treatment group received a free sample of maize flour derived from *Bazooka* to try at home after the demonstration. In the control villages, these events are not organized.[4]

## 2.2 Treatments

The first intervention involves providing a seed sample pack to the household member responsible for most maize cultivation decisions. This sample pack contains *Bazooka* maize, which was released by the National Agricultural Research Organization (NARO) in Uganda in 2013 and is currently available in the market but not yet widely adopted by farmers. Some of *Bazooka*'s key features include high yield, resistance to drought, and resistance to diseases like maize lethal necrosis (Akwango-Aliau et al., 2022). Indeed, at baseline, only about 7 percent of sampled farmers reported growing *Bazooka* on a randomly chosen plot. Specifically, we provided 1 kg bags of *Bazooka* seed, which is enough to plant about one-eighth of an acre. Given that the average farmer in our sample cultivates 1.24 acres of maize, this seed covers approximately 10 percent of their total cultivated area.

The second intervention consists of a cooking demonstration and tasting event. Here, both male and female co-heads of sampled households in the treatment villages were invited to a central place (the village chairperson's residence) for a facilitated meeting. The facilitator started by asking the group to mention the most commonly grown varieties by farmers in their village. These varieties are grouped into "improved varieties" and "local varieties" on a flip chart.[5] Farmers were then asked to rank the two categories based on ratings of various consumption attributes by a show of hands. To facilitate the discussion, flip charts were pre-filled with the five consumption traits most commonly mentioned during focus group discussions held during the design phase of the study: taste, texture, color, aroma, and the degree to which the flour expands during cooking. Farmers could add as many additional traits as they saw fit.

After the rating exercise, sessions proceeded with the cooking demonstration and blind taste testing. The facilitator asked a volunteer participant to prepare *posho*, a thick, dense porridge made by mixing maize flour with boiling water until it reaches a dough-like consistency. The volunteer cook then prepared two meals: one using flour obtained from a local variety and one using flour derived from *Bazooka*. Neither the cook nor the other participants were aware of which flour corresponds to which maize type. The research team provided all necessary utensils for the session, including a gas stove, pots, aprons, and even a chef's hat. We ensured that the two dishes differed only in terms of the flour used by employing the same cook and starting with identical amounts of flour, measured on a weighing scale. The resulting dishes were displayed on a

[4] Farmers in pure control villages under both factors received a "token of appreciation" of similar value to the seed trial pack/maize flour bag to account for potential income effects.

[5] The terms for the seed types in the local language were "Dhuuma Omulongosemu" for "seed of an improved variety" and "Dhuuma Omusoga" for local seed. The latter is derived from the name of the region, Busoga.

table, and participants were invited to taste the two varieties, simply labeled by their position as the variety on the “left” and the variety on the “right.” The participants then rated the two varieties on the various consumption attributes again, voting on which of the two samples is superior for each attribute by a show of hands.

Finally, the results were discussed within the group and participants were informed that one sample was made from flour obtained from local maize while the other was made from an improved maize variety called *Bazooka*. After being asked to guess which was which, the facilitator gathered the guesses and revealed the correct answers.[6]

## 2.3 Estimation and Inference

We will use analysis of covariance (ANCOVA) models to assess the impact of the interventions, focusing specifically on the intent-to-treat effect. Given that randomization was conducted at the village level, we will estimate the following equation:

$$Y_{ij} = \alpha + \beta_S T_j^S + \beta_D T_j^D + \beta_I T_j^S T_j^D + \delta Y_{ij}^B + \varepsilon_{ij} \tag{1}$$

where $T_j^S$ is an indicator variable that takes the value of one if village $j$ was randomly assigned to the seed sample pack intervention (and zero otherwise), and $T_j^D$ is an indicator variable that is one if village $j$ was randomly assigned to the cooking demonstration and blind tasting intervention (and zero otherwise). Outcomes are measured at the individual level ($Y_{ij}$). We also allow for an interaction effect between the two interventions and control for baseline outcomes $\left(Y_{ij}^B\right)$ to improve precision. We will apply a cluster-robust variance estimator with the bias-reduced linearization (CR2) small-sample correction (Imbens and Kolesar, 2016), with standard errors clustered at the level of randomization (village level).

Factorial designs are commonly employed to evaluate multiple treatments within a single experiment. While our design is powered for a complete set of interactions (as in equation 1), we may wish to enhance statistical power by pooling observations across the orthogonal treatments if we find that a treatment effect is smaller than the minimal detectable effect size assumed during power calculations. However, pooling treatment cells to enhance statistical power can lead to biased estimates of the main treatment effects if there is an interaction between the treatments (Muralidharan, Romero, and Wüthrich, 2023). To control for this, we will treat the orthogonal treatment as a covariate we want to

[6] During the pilot of this intervention, a large majority of farmers initially stated that the local seed excelled in nearly all dimensions, such as having a sweeter taste, whiter appearance, and better aroma (which is similar to what Timu et al. (2014) find for sorghum in neighboring Kenya). However, during the tasting, almost all farmers rated the sample made from *Bazooka* maize as superior. After the tasting, most farmers incorrectly identified the superior sample as being cooked from a local maize variety, when in fact, it was prepared using *Bazooka* maize. This revelation sparked extensive discussions within the group.

adjust for and interact the treatment variable with the demeaned orthogonal treatment (Lin, 2013):

$$Y_{ij} = \alpha + \beta_M T_i^M + \beta_O \left(T_i^O - \bar{T^O}\right) + \beta_I T_i^M \left(T_i^O - \bar{T^O}\right) + \delta Y_{0ij}^B + \varepsilon_{ij} \tag{2}$$

where now $T_i^M$ is a dummy for the main treatment (the seed sample pack or the cooking demonstration respectively) and $T_i^O$ is a dummy for the orthogonal treatment (which enters in deviations from its means).[7]

Since we evaluate treatment effects across a range of outcomes, it is essential to address the multiple comparisons problem. As prespecified, we address the issue following Anderson (2008) and aggregate various outcome measures within a given family into summary indices. Each index is calculated as a weighted mean of the standardized values of the outcome variables. The weights for this efficient generalized least squares estimator are determined to maximize the information captured by the index, giving less weight to outcomes that are highly correlated with one another. However, because it may also be useful to understand changes in specific outcomes within a given family rather than just changes in index values, we also present the coefficients on each outcome, controlling the false discovery rate (FDR) by using sharpened two-stage q-values proposed by Benjamini, Krieger, and Yekutieli (2006).

## 2.4 Timeline

Our experiment runs over two consecutive agricultural seasons. This is because the main outcome of interest for the trial pack treatment is not whether farmers plant the trial pack, but whether the experimentation facilitated by the trial pack in one season leads to the variety's continued use in the subsequent season. As such, outcomes must be measured after the second season. Conversely, the cooking demonstration and tasting session intervention does not require an entire planting season to implement. Hence, this intervention is administered at the beginning of the second experimental season so as to measure the outcomes of both interventions at the same time.

Fortunately, the study area experiences two maize growing seasons each calendar year. The first season, locally known as *Entoigo*, runs from March/April to June/July, while the second season, referred to as *Nsambya*, extends from August/September to November/December. We distributed the seed sample packs along with baseline data collection a few months before planting commenced for *Entoigo* 2023, such that farmers could plant their trial packs during this season. After *Entoigo* and before the start of *Nsambya*, the cooking demonstrations and tasting sessions were held. Endline data was collected in February 2024, after the conclusion of *Nsambya*. This timeline is also depicted in Figure 1.

[7] It is important to note that the estimand of the respective treatments in Equation 2 changes. For instance, while the estimand for the seed sample pack treatment in Equation 1 is the effect of the treatment in and of itself, the estimand in Equation 2 is a weighted average of the estimand of the seed sample pack treatment of Equation 1 and the effect of the seed sample pack in the presence of the cooking demonstration and testing treatment.

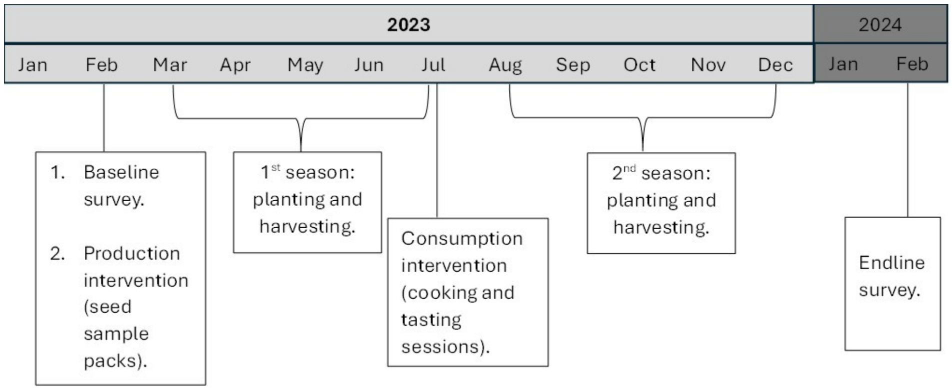


Figure 1: Timeline

# 3 Sample

Sample size was determined through a series of power simulations detailed in the pre-registered pre-analysis plan.[8] The simulations resulted in a sample design of 148 villages, with 10 households in each village. In this setup, 74 villages (740 households) would receive a free sample pack, and 74 villages (740 households) would be exposed to the cooking demonstration and blind tasting treatment. Approximately half of the villages in each treatment group (or around 37 villages comprising 370 households) would receive both treatments. To counteract potential attrition which would decrease power, we increased the sample size by adding 2 additional villages in each treatment cell. This leads to a total sample size of 1,560 households located in 156 villages.

With this design, sample size, and assumptions about outcome variable and minimum detectable effect sizes detailed in the pre-analysis plan, we note that we are not powered to detect both main effects and the interaction simultaneously. Specifically, we can estimate a joint positive effect for both treatments and their interaction at the 5-percent significance level with only 68 percent power. However, when we only require one hypothesis to be detected, we achieve power levels in excess of the conventional 80 percent.

[8]The primary outcome used in these simulations is a binary indicator for the type of seed used by the farmer (1 if the farmer used fresh seed of an improved variety, 0 otherwise). Data from a previous project, which included 3,450 smallholder maize farmers across 345 villages, were used to estimate the intra-cluster (within-village) correlation for this outcome (Miehe et al., 2023a). We assumed a 13.5–percentage point increase (over a baseline adoption percentage of 30 percent) for both the seed sample treatment and the cooking demonstration treatment, and a 23.5–percentage point increase for the interaction effect as minimal detectable effect size. The R code used for the simulations is available here. The pre-analysis plan can be accessed here.

## 3.1 Context

The study was conducted in Eastern Uganda in an area that is also known as the Busoga Kingdom. The main income-generating activity in this area is smallholder maize production. We selected our sample from four districts—Bugiri, Iganga, Kamuli, and Mayuge—chosen for their relatively low adoption rates of the improved seed variety (*Bazooka*) and their well-established network of agro-input dealers, which helps mitigate access issues. To obtain a representative random sample of farmers in Busoga Kingdom, villages were selected with probability proportional to the number of households within each village. Within each sampled village, 10 households were randomly chosen to participate in the study.

## 3.2 Descriptive Statistics and Baseline Balance

We pre-registered 10 variables to assess balance in our design during baseline data collection. These variables were selected to offer a comprehensive description of a representative farmer in our sample. Five of the variables are characteristics that are unlikely to be influenced by the intervention, while the other five are drawn from the pre-registered primary and secondary endline outcomes.

Table 1 shows sample means in the first column (and standard deviations below). We see that the average household head in our sample was about 49 years old at the time of the baseline survey. About half of the household heads had finished primary education, and in 20 percent of the households, the household head was a woman. Households in the area are large, with on average about 8 to 9 members. The average distance to the nearest agro-input shop where maize seed of an improved variety can be bought is about 4 kilometers.

For variables that will be used to assess impact at endline, we first inquired whether farmers had used "quality maize seed, such as an Open Pollinating Variety (OPV) or hybrid seed, on any of their plots during the previous season (*Nsambya* of 2022)." According to the baseline data, approximately 40 percent of households answered affirmatively to this question. Subsequently, we posed a more specific question regarding the exact type of seed used on a randomly selected plot.[9] The seed type of interest was *Bazooka*, the hybrid seed variety that is also utilized in our experiment. At baseline, only about 7 percent of farmers reported having used *Bazooka* seed on the randomly selected plot in the previous season. We also asked where the seed used on the randomly selected plot was obtained from. Results indicate that approximately 30 percent of farmers sourced their seed from formal channels, such as agro-input dealers, non-governmental organizations, or the government extension system. Conversely, 54 percent of farmers reported reusing seed from previous seasons, with some having used it for more than four seasons despite recommendations against using hybrid varieties more than once and against using OPVs more than four times,

[9]See Section 4.1 for more information on the rationale for using of a randomly selected plot.

at the risk of losing any yield advantage. Finally, the average farmer harvested about 390 kilograms per acre on the randomly selected plot at baseline.

The table also reports differences between the relevant treatment and control groups, as estimated through the pooled model (Equation 2) as well as the fully interacted model (Equation 1). In particular, the second column in Table 1 corresponds to $\beta_M$ in Equation 2 for the seed sample pack treatment (in which case the cooking demonstration and tasting treatment is considered the orthogonal treatment and controlled for). In the third column, this is reversed, showing $\beta_M$ in Equation 2 for the cooking demonstration and tasting treatment (with the seed sample pack treatment now considered the orthogonal treatment and controlled for). The fourth, fifth, and sixth columns correspond to $\beta_S$, $\beta_D$, and $\beta_I$ respectively in Equation 1.

The estimates indicate good overall balance. The proportion of male household heads is about 4 percentage points lower in the subsample assigned to the cooking demonstration treatment compared to those not exposed to the intervention, but this difference is only significant at the 10 percent level. Considering that out of 50 comparisons, we would expect 5 outcomes to be significant at the 10 percent level by chance alone, we conclude that the randomization appears to have been effective.

### 3.3 Attrition and Compliance

Attrition was minimal: during endline, we successfully located all but four of the 1,560 households interviewed at baseline. However, some of these households could not be interviewed due to circumstances such as burial or illness, or they refused participation, reducing the effective sample size at endline to 1,538.

One of the first questions we asked was whether farmers recalled the treatment, irrespective of their treatment group. This question serves as a useful proxy to assess compliance. For the sample pack treatment, 98 percent of farmers in the treatment group indicated that they received a seed sample pack from us in March 2023. Furthermore, only 91.4 percent of farmers in the control group indicated that they had not received a seed pack from us. For the cooking demonstration treatment, 92 percent of farmers in the treatment group recalled being invited to a cooking and tasting demonstration. Meanwhile, 96 percent of farmers in the control group did not recall a cooking and tasting demonstration. Given this evidence of high compliance, we feel a focus on intent-to-treat is appropriate.

## 4 Results

### 4.1 Adoption

The use of seed of improved varieties by farmers is the primary outcome of interest in this study. Therefore, Table 2 investigates if farmers use seed of improved varieties in general, while Table 3 reports on more detailed outcomes

Table 1: Baseline Balance

| | | *Pooled model* | | *Interacted model* | | |
|---|---|---|---|---|---|---|
| | mean | sample | cons | sample | cons | interact |
| Age of household head (in years) | 48.62 | -0.31 | -0.65 | -1.53 | -1.87 | 2.45 |
| | (13.58) | (0.85) | (0.85) | (1.31) | (1.22) | (1.69) |
| Household head has finished primary education? | 0.51 | 0.02 | 0.00 | 0.00 | -0.02 | 0.04 |
| | (0.50) | (0.03) | (0.03) | (0.05) | (0.04) | (0.06) |
| Gender of household head (1=male) | 0.80 | -0.03 | -0.04$^{+}$ | -0.03 | -0.04 | 0.00 |
| | (0.40) | (0.03) | (0.03) | (0.03) | (0.03) | (0.05) |
| Household size | 8.12 | -0.02 | -0.01 | -0.05 | -0.03 | 0.05 |
| | (3.60) | (0.03) | (0.03) | (0.04) | (0.04) | (0.06) |
| Distance of homestead to nearest agro-input shop (km) | 4.08 | -0.01 | 0.04 | 0.01 | 0.06 | -0.05 |
| | (3.54) | (0.10) | (0.10) | (0.14) | (0.15) | (0.19) |
| Has used quality maize seed on any plot in last season? | 0.40 | -0.04 | -0.02 | -0.03 | -0.01 | -0.02 |
| | (0.49) | (0.03) | (0.03) | (0.05) | (0.04) | (0.07) |
| Has used the promoted seed (Bazooka) on a randomly chosen plot in the last season? | 0.07 | -0.01 | -0.01 | 0.02 | 0.02 | -0.06 |
| | (0.26) | (0.02) | (0.02) | (0.02) | (0.03) | (0.04) |
| Seed on random plot was obtained from formal seed source? | 0.30 | -0.04 | 0.02 | -0.01 | 0.05 | -0.06 |
| | (0.46) | (0.03) | (0.03) | (0.04) | (0.04) | (0.06) |
| Used seed that is recycled more than 3 seasons on randomly selected plot? | 0.54 | 0.02 | 0.03 | 0.00 | 0.02 | 0.04 |
| | (0.50) | (0.04) | (0.04) | (0.05) | (0.05) | (0.07) |
| Maize yields on a randomly chosen plot in last season (kg/acres) | 386.76 | -0.06 | 0.00 | -0.04 | 0.02 | -0.04 |
| | (299.89) | (0.06) | (0.06) | (0.07) | (0.07) | (0.11) |

Note: Column (1) reports sample means at baseline and standard deviations below; columns (2)–(3) report differences between treatment and control groups estimated using the pooled model of Equation 2; (4)–(5) report differences between treatment and control groups estimated using the fully interacted model of Equation 1; column (6) is the interaction effect. Standard errors are below the estimates and are clustered at the level of randomization; **, *, and + denote significance at the 1, 5, and 10% levels. Household size, distance to nearest agro-input shop, and productivity is transformed using the inverse hyperbolic sine transformation (means and standard deviations are in levels).

on seed use and practices on one (randomly selected) plot within the farm household. As mentioned in Section 2.3, outcomes are combined in a summary index following Anderson (2008). The structure of the results tables is the same as the one used in Table 1. Each table reports overall sample means (this time at endline; column 1) as well as average treatment effect estimates for the pooled model in Equation 2 (columns 2 and 3) and the fully interacted model in Table 1 (columns 4 to 6).

Before discussing the main results, we note that at endline only about 25 percent of farm households used maize seed of an improved variety on at least one plot in the second season of 2023 (see Table 2), which is significantly lower than the 40 percent reported during baseline (see Table 1). However, this is most likely due to a change in the way the question used to measure seed use was asked; at baseline, we asked the farmer whether they had used "quality seed" on any plot, while at endline we asked which varieties were used on each individual plot, and categorize quality seed of an improved variety as fresh seed of a hybrid variety or an OPV recycled a maximum of three times, obtained from a trusted source (that is, bought from agro-input shop, seed company or local seed business, or obtained from a public extension system or an NGO that supports agriculture).

Looking at the adoption index values in Tables 2 and 3, we see an overall negative effect on adoption outcomes of the sample pack treatment and little systematic impact of the tasting session treatment. We also do not see strong evidence that there is an additional interaction effect of both treatments. Turning to specific outcome indicators in Table 3, we find that the seed sample pack intervention reduced the likelihood of adoption of improved varieties, regardless of the model used. This reduction is substantial, amounting to approximately half of the mean adoption rate. Conversely, we do not observe any change in the use of improved varieties as a result of the cooking demonstration and tasting session. We also examine the adoption of *Bazooka* specifically, counting adoption as planting fresh seed from a trusted source. Overall, about 9 percent of farmers use fresh *Bazooka* seed on at least one plot. We do not see a negative effect of the seed sample pack on this outcome. In addition, we find that farm households exposed to the cooking demonstration intervention are more likely to use fresh *Bazooka* seed in the season following the intervention.

Next, using the same definition of maize seed of an improved variety used to define the first outcome, we consider some intensive margin adoption indicators, including number of plots, share of plots, total area, and share of maize cultivation area that are planted using improved varieties. It is critical to look at both absolute changes and relative changes in maize planted because the intervention could have changed the total number of plots used for cultivation. We find that seed of an improved variety was planted on 0.33 plots in the entire sample. The seed sample pack reduced the number of plots on which seed of an improved variety was planted by 0.16 and the share of plots on which improved varieties were planted by 13 percentage points. In terms of area planted, we find that, on average, households planted about 0.34 acres with seed of an improved variety. However, in households that received a seed sample pack, the area planted with

Table 2: Adoption

| | | *Pooled model* | | *Interacted model* | | | |
|---|---|---|---|---|---|---|---|
| | mean | sample | demo | sample | demo | interact | nobs |
| Has used seed of an improved variety on any plot in last season?† | 0.25 | -0.13** | 0.04+ | -0.14** | 0.03 | 0.02 | 1488 |
| | (0.43) | (0.03) | (0.02) | (0.03) | (0.03) | (0.05) | |
| Has used fresh Bazooka on any plot in last season in last season?† | 0.09 | 0.02 | 0.05** | 0.02 | 0.05* | -0.01 | 1495 |
| | (0.28) | (0.02) | (0.02) | (0.02) | (0.02) | (0.03) | |
| Number of plots planted with improved varieties | 0.33 | -0.16** | 0.05 | -0.18** | 0.03 | 0.05 | 1495 |
| | (0.64) | (0.04) | (0.04) | (0.05) | (0.05) | (0.08) | |
| Number of plots with improved varieties as share of total number of plots | 0.23 | -0.13** | 0.03 | -0.13** | 0.03 | 0.01 | 1494 |
| | (0.41) | (0.03) | (0.03) | (0.03) | (0.03) | (0.05) | |
| Area planted with improved varieties (acres) | 0.34 | -0.16** | 0.04 | -0.22** | -0.02 | 0.12 | 1495 |
| | (0.81) | (0.05) | (0.05) | (0.06) | (0.06) | (0.10) | |
| Area planted with improved varieties as a share of total maize cultivation area | 0.23 | -0.13** | 0.03 | -0.14** | 0.03 | 0.01 | 1495 |
| | (0.41) | (0.03) | (0.03) | (0.03) | (0.03) | (0.05) | |
| Index | -0.06 | -0.18** | 0.08 | -0.21** | 0.06 | 0.05 | 1494 |
| | (0.85) | (0.05) | (0.05) | (0.06) | (0.06) | (0.11) | |

Note: Column (1) reports sample means at baseline and standard deviations below; columns (2)–(3) report differences between treatment and control groups estimated using the pooled model of Equation 2; (4)–(5) report differences between treatment and control groups estimated using the fully interacted model of Equation 1; column (6) is the interaction effect. Standard errors are below the estimates and are clustered at the level of randomization; **, *, and + denote significance at the 1, 5, and 10% levels based on sharpened q-values (Benjamini, Krieger, and Yekutieli, 2006). † indicates that baseline outcome was controlled for in the regression.

an improved seed variety was 0.16 acres less compared to households that did not receive a seed sample pack. We also observe a reduction in the proportion of the total area planted with seed of an improved variety, suggesting that the intervention led farmers to switch from planting seed of an improved variety to planting local or recycled seed.

Turning to the Table 3 on outcomes related to adoption on a randomly selected plot, we see similar results.[10] At the plot level, there are negative effects on the adoption of seed of an improved variety for the seed sample pack treatment, but a positive effect on the use of fresh *Bazooka* seed from the cooking demonstration. To look at intensive margin adoption at the plot level, we consider the total quantity of seeds on an improved variety planted, as well as quantity per acre. The seed trial packs lead to reductions in both measures, while the tasting session treatment has no detectable impact. Interestingly, the reduced use of improved varieties in the seed sample pack group did not lead to detectable reductions in plot-level maize production or productivity (yield). There is, however, a significant positive effect of the cooking demonstration and tasting sessions actually on maize yields, at least in the pooled model. In particular, we find a 13 percent increase in maize productivity (as we use log transformations in the regression). This makes sense given that the cooking demonstration group was more likely to plant *Bazooka*, which is a particularly high yielding improved variety.

At first glance, the results of the seed sample pack intervention may seem counterintuitive; the intervention aimed to increase the adoption of improved varieties in future planting seasons, yet we observe a decline. This can be explained by the fact that many farmers who received the *Bazooka* seed sample packs chose to recycle seeds from the harvested grain rather than purchasing fresh *Bazooka* seeds from agro-input suppliers, NGOs, or government programs. According to our definition of seed of improved varieties, only fresh *Bazooka* seed obtained from a credible source qualifies as an improved variety, while recycled *Bazooka* is classified as local seed. However, if we redefine adoption to include reused *Bazooka* seeds, we find that over 60 percent of farmers who received the sample pack continued growing *Bazooka* in the next season.

Moreover, the fact that we observe an overall decline in fresh improved seed variety use—along with the insignificant effect of the sample pack on fresh *Bazooka* purchases—indicates that OPVs and other (non-*Bazooka*) hybrid seed varieties were likely crowded out. This is probably because farmers, encouraged by the high yields from the trial pack, opted to continue using recycled *Bazooka* rather than investing in fresh hybrids or recent OPVs. Meanwhile, farmers in the control group, potentially dissatisfied with their local seeds, were more likely

[10] The decision to collect detailed data on only one randomly selected plot per household, rather than on all plots, was based on the generally high correlation of technology use, input use, and management practices between plots within a household. By focusing on a single plot, we aimed to increase the number of farmers included in the sample, thereby enhancing statistical power. While one might be concerned that farmers could use different seed varieties on different plots, potentially leading to misclassification of adopters if the "wrong" plot is chosen, our data indicates that this is not a significant issue.

Table 3: Adoption on random plot

| | | *Pooled model* | | *Interacted model* | | | |
|---|---|---|---|---|---|---|---|
| | mean | sample | demo | sample | demo | interact | nobs |
| Has used improved variety on randomly selected plot in last season (yes=1) | 0.23 | -0.12** | 0.03 | -0.13** | 0.02 | 0.02 | 1495 |
| | (0.42) | (0.02) | (0.02) | (0.03) | (0.03) | (0.05) | |
| Has used fresh Bazooka on randomly selected plot in last season (yes=1) | 0.07 | 0.01 | 0.04* | 0.02 | 0.05* | -0.02 | 1495 |
| | (0.26) | (0.01) | (0.01) | (0.02) | (0.02) | (0.03) | |
| Quantity of improved variety used on randomly selected plot (kg) | 1.33 | -0.89** | -0.13 | -1.27** | -0.51 | 0.77+ | 1438 |
| | (3.18) | (0.18) | (0.17) | (0.25) | (0.28) | (0.35) | |
| Quantity of improved variety used on randomly selected plot (kg/acre) | 1.32 | -0.78** | -0.05 | -1.12** | -0.39 | 0.67 | 1411 |
| | (2.83) | (0.17) | (0.17) | (0.23) | (0.24) | (0.34) | |
| Maize production (log) | 331.20 | -0.07 | 0.11+ | -0.09 | 0.09 | 0.04 | 1410 |
| | (340.92) | (0.06) | (0.06) | (0.08) | (0.09) | (0.12) | |
| Maize productivity (log) | 383.50 | 0.01 | 0.13* | -0.01 | 0.11 | 0.04 | 1375 |
| | (292.76) | (0.05) | (0.05) | (0.08) | (0.07) | (0.11) | |
| Index | -0.07 | -0.09* | 0.02 | -0.16** | -0.05 | 0.13+ | 1331 |
| | (0.62) | (0.04) | (0.04) | (0.05) | (0.05) | (0.07) | |

Note: Column (1) reports sample means at baseline and standard deviations below; columns (2)–(3) report differences between treatment and control groups estimated using the pooled model of Equation 2; (4)–(5) report differences between treatment and control groups estimated using the fully interacted model of Equation 1; column (6) is the interaction effect. Standard errors are below the estimates and are clustered at the level of randomization; **, *, and + denote significance at the 1, 5, and 10% levels based on sharpened q-values (Benjamini, Krieger, and Yekutieli, 2006). Production and productivity are log transformed; means and standard deviations are in levels. All regressions include baseline outcome as control.

to seek out fresh hybrids or use OPVs that are recycled a maximum of three times. However, they tended to opt for cheaper alternatives rather than purchasing *Bazooka*, which is more expensive than more popular but lower yielding OPVs.

## 4.2 Decision Making

In addition to our main hypotheses about the effects of the interventions on the adoption of improved varieties, we also hypothesized that highlighting the consumption traits of improved seed varieties may increase women's influence in decisions concerning seed selection and the use of harvested maize, as it is more culturally acceptable for women to make decisions in the household food preparation and consumption domains (Kramer and Trachtman, 2024). In Uganda, as in many agriculture-based countries with pronounced gender norms, men typically handle production and marketing decisions, while women are more often involved in domestic responsibilities such as cooking. The cooking demonstration and tasting session might increase men's awareness that maize involves more than just yield, potentially creating opportunities for women to participate more in decision-making processes.

To explore this, we asked about decision-making within households. Specifically, we inquired about who decided which seed to use on the randomly selected plot, as well as who decided what to do with the harvest for that plot. We consider a woman to be involved in a decision if the decision was made solely by the woman, jointly by the woman and her husband, or if her husband made the decision after consulting the woman (as opposed to her husband deciding unilaterally).

Table 4 indicates that women are already highly engaged in decision-making regarding seed use and harvest management. Contrary to our expectations, the consumption intervention does not increase women involvement. In anything, the index suggests that the seed sample pack may increase women's involvement in decision making, though the effect is significant only at the 10 percent level.

## 4.3 Well-being and Food Security

Increasing the adoption of improved seed varieties is a means to an end, as farmers ultimately aim to improve their food security and overall well-being. Therefore, Table 5 evaluates the interventions' effects on key welfare and food security indicators. Judging by the index values, we find no effects from the treatments on overall welfare and food security. There is a marginally significant positive effect on the interaction term in the full model, though we cannot rule out a simple income effect of having received both a seed trial pack and a bag of flour, as opposed to one or the other.

The effects on individual indicators broadly tell the same story, showing little in the way of welfare gains. The first two indicators assess subjective measures of relative well-being, both within the village and over time. In particular, we asked if the respondent felt that their household was better off, about the same,

Table 4: Impact on women co-head involvement (random plot)

| | | Pooled model | | Interacted model | | | |
|---|---|---|---|---|---|---|---|
| | mean | sample | cons | sample | cons | interact | nobs |
| Woman involved in decision what to plant? | 0.85 | 0.04 | -0.03 | 0.01 | -0.06 | 0.05 | 1098 |
| | (0.36) | (0.03) | (0.03) | (0.04) | (0.04) | (0.05) | |
| Women involved in what to do with harvest? | 0.86 | 0.05 | -0.04 | 0.02 | -0.07 | 0.05 | 1098 |
| | (0.35) | (0.03) | (0.03) | (0.04) | (0.04) | (0.05) | |
| Index | -0.02 | $0.12^{+}$ | -0.11 | 0.05 | -0.18 | 0.15 | 1098 |
| | (0.96) | (0.07) | (0.07) | (0.10) | (0.11) | (0.14) | |

Note: Column (1) reports sample means at baseline and standard deviations below; columns (2)–(3) report differences between treatment and control groups estimated using the pooled model of Equation 2; (4)–(5) report differences between treatment and control groups estimated using the fully interacted model of Equation 1; column (6) is the interaction effect. Standard errors are below the estimates and are clustered at the level of randomization; **, *, and + denote significance at the 1, 5, and 10% levels based on sharpened q-values (Benjamini, Krieger, and Yekutieli, 2006). All regressions include baseline outcome as control.

or worse off in terms of income and consumption than the average households in the community and create an indicator variable which is equal to one if the respondent answered that they were better off and zero otherwise. Similarly, we asked if the respondent felt that their household was better off, about the same, or worse off in terms of income and consumption than six months earlier and construct an analogous indicator. Approximately 35 percent of farm households report that they perceive themselves as better off compared to the average within their village. There is no significant change in this perception following either the seed sample pack nor the cooking demonstration and tasting session. Additionally, 42 percent of households believe they are better off than they were six months ago—approximately one agricultural season prior. Notably, there is some indication that farmers in the seed sample pack group are more likely to feel that their well-being improved over time compared to those who did not receive a seed sample pack. This may be due to the perceived benefits from planting the seed sample pack, either through real or perceived harvest increases (despite yields not showing a significant increase on average, as detailed in Table 3).

Next, we use two questions from the The Household Food Insecurity Access Scale (HFIAS), one that aligns with the "food preference" dimension, which assesses whether people had to compromise on their preferred diet due to financial or food constraints, and one that captures "reducing quantity,"a more severe form of food insecurity where people eat smaller portions or skip meals due to lack of resources (Coates, Swindale, and Bilinsky, 2007).[11] Table 5 shows that 49 percent of households indicate that in the past month they were always able to eat what they wanted, whereas percent of households indicate that in the past month they always had the desired quantities of food they wanted. We do not find any impact of the interventions on these outcomes.

Finally, we approximate consumption expenditure by asking farmers to report how much money was spent in the week prior to the survey on 14 of the most consumed items in the area (maize, sorghum, millet, rice, cassava, sweet potatoes, beans, groundnuts, fruits, vegetables, sugar, cooking oil, soap, and airtime). On average, a household spent about 84905, which at the time of the survey corresponds to about US$24. We also do not find that our treatments affected consumption expenditure.

## 5 Mechanisms

In this section, we explore various secondary and intermediary outcomes to investigate potential impact pathways. We start by looking at changes in awareness about and general attitudes toward improved varieties, then focus on changes in perceptions related specifically to the consumption and production traits of improved varieties. Finally, given that the decision to recycle seeds emerged as a key mechanism explaining the negative affect on adoption of

[11] In our analysis, as we want to focus on positive outcomes, we take the inverse and measure food security instead of insecurity.

Table 5: Welfare and food security

| | | *Pooled model* | | *Interacted model* | | | |
|---|---|---|---|---|---|---|---|
| | mean | sample | cons | sample | cons | interact | nobs |
| Better off than average of village? | 0.35 | 0.02 | 0.00 | 0.00 | -0.02 | 0.05 | 1504 |
| | (0.48) | (0.03) | (0.03) | (0.05) | (0.05) | (0.07) | |
| Better off than 6 months ago? | 0.42 | 0.12** | -0.02 | 0.10 | -0.05 | 0.06 | 1531 |
| | (0.49) | (0.03) | (0.03) | (0.05) | (0.05) | (0.07) | |
| Can always eat what they want? | 0.49 | 0.03 | 0.03 | -0.07 | -0.07 | 0.21 | 1538 |
| | (0.50) | (0.05) | (0.05) | (0.07) | (0.07) | (0.10) | |
| Can always eat quantity needed? | 0.59 | 0.08 | -0.04 | 0.01 | -0.10 | 0.13 | 1538 |
| | (0.49) | (0.04) | (0.04) | (0.05) | (0.06) | (0.08) | |
| Consumption expenditure (*1000 UGX/week) | 84905 | -2050 | -2742 | -1795 | -2488 | -510 | 1507 |
| | (42299) | (3657) | (3659) | (5253) | (5379) | (7315) | |
| Index | -0.01 | 0.05 | -0.02 | -0.02 | -0.10 | $0.15^{+}$ | 1471 |
| | (0.59) | (0.05) | (0.05) | (0.06) | (0.07) | (0.09) | |

Note: Column (1) reports sample means at baseline and standard deviations below; columns (2)-(3) report differences between treatment and control groups estimated using the pooled model of Equation 2; (4)-(5) report differences between treatment and control groups estimated using the fully interacted model of Equation 1; column (6) is the interaction effect. Standard errors are below the estimates and are clustered at the level of randomization; **, *, and + denote significance at the 1, 5 and 10% levels based on sharpened q-values (Benjamini, Krieger, and Yekutieli, 2006).

fresh seeds in the seed sample pack treatment, we also further explore farmers' rationales for this decision.

### 5.1 Awareness About and General Attitudes Toward Improved Varieties

One reason that farmers may have changed their behavior around the decision to plant improved varieties, and *Bazooka* in particular, is if the the intervention affected farmers awareness of and general sentiment towards improved varieties. We explore this hypothesis using the family of outcomes presented in Table 6. When summarizing these outcomes into an index, we observe a significant positive impact from the seed sample pack on this set of outcomes. In contrast, the effect of the cooking demonstration and tasting session, while positive, is much smaller, and hence only marginally significant.

Looking at specific outcomes, we start by testing whether the interventions increased awareness of improved maize seed varieties, specifically *Bazooka*. We asked farmers to list as many improved maize seed varieties as they could name, and enumerators recorded the number of varieties mentioned. Second, we directly inquired whether the farmer was familiar with a maize variety called "*Bazooka*." The top two rows of Table 6 suggest an impact on varietal knowledge resulting from the two interventions. On average, farmers are aware of approximately 2 to 3 different maize varieties. Both interventions lead farmers to name around 0.4 additional varieties. Overall, 82 percent of farmers in our sample report being familiar with the *Bazooka* variety. The seed pack intervention increases the probability that farmers report knowing about *Bazooka* by 26 percentage points compared to non-sample pack group farmers, likely because seed sample packs prominently displayed the variety's name on the packaging. In contrast, the cooking and tasting demonstration shows a much smaller and marginally significant 6-percentage point effect, likely because this intervention had a more general focus on the consumption traits of improved varieties rather than promoting *Bazooka* specifically.[12]

In terms of other more general attitudes toward improved varieties, one of the reasons why seed sample packs are distributed for free is to mitigate the perceived risk associated with trying out new varieties. To assess changes in perceived risk in response to the interventions, we asked farmers to rate how likely they believe using improved varieties would result in lower yields compared to local varieties. Responses were recorded on a 4-point Likert scale, ranging from "very likely" (improved varieties will yield less than local) to "very unlikely" (improved varieties will yield more than local). We repeated this question specifically for *Bazooka* as well, but only for farmers who reported

[12] The more general focus was deliberate as we aimed to more generally correct any misconceptions about the taste of improved varieties and did not want to be seen as promoting a particular commercial variety. However, we did mention that the maize flour we used (and also provided a take home sample of) came from *Bazooka*. This is likely why the result for the cooking demonstration is small but still significant (at least in the pooled model), and why we do see that farmers in demo group also adopted more fresh *Bazooka* (see Tables 2 and 3)

familiarity with the variety. We constructed an indicator for downside risk, which is set to 1 if the farmer responded with a 1 or 2 on the Likert scale (indicating "very likely" or "somewhat likely" that improved variety will yield less). Our findings reveal that perceived downside risk is generally limited, and neither intervention significantly affected risk perceptions related to improved varieties in general, nor the specific variety used in the study.

An additional rationale for subsidizing or providing seed at no cost is to harness potential spillover effects to enhance adoption, as it is well known that farmers learn form others about new technologies (Conley and Udry, 2010; Van Campenhout, 2021). To examine whether our interventions influenced peer learning, we included questions on whether farmers recommended any improved varieties to others. A similar question was posed specifically regarding *Bazooka*, but only for those farmers who were familiar with this variety.

Our findings indicate that a substantial proportion of farmers (59 percent) recommended improved varieties to their peers. Notably, the likelihood of recommending improved varieties is 29 percentage points higher among those who received the seed sample pack. When focusing specifically on *Bazooka*, the difference becomes even more pronounced: receiving a seed sample pack increased the probability of recommending *Bazooka* by 38 to 44 percentage points, depending on the model used.

Finally, we examine farmers' intentions regarding future use of improved varieties as another assessment of their general attitudes toward these varieties. Although in practice we observe relatively low rates of adoption of improved varieties and of fresh *Bazooka*, 83 percent of farmers report an intention to use improved varieties in the future and 36 percent report an intention to use *Bazooka*. While there is no impact of either treatment on the reported intention to use improved varieties, we see that in the group which received a seed sample pack, the percentage reporting an intention to plant *Bazooka* is 16 to 20 percentage points higher than in the group that did not receive a seed sample pack. However, we do not necessarily know if this means that farmers intend to recycle their *Bazooka* from the sample pack yet again, or to purchase new *Bazooka*.

## 5.2 Trait Perceptions

### 5.2.1 Perceptions of Consumption Traits

Farmers may perceive that crops grown from local varieties are tastier than crops grown from improved varieties (Pícha, Navrátil, and Švec, 2018; Timu et al., 2014). The cooking demonstrations and tasting sessions were designed to alter these potentially biased perceptions about the consumption qualities of maize from improved varieties. Additionally, if after farmers plant the seed sample pack, they process the resulting harvest separately and use it for home consumption, they may revise their beliefs about the consumption traits of these improved varieties as well.

To assess whether our interventions influence farmers' perceptions of the con-

Table 6: Knowledge, risk, social learning, and intentions

| | | *Pooled model* | | *Interacted model* | | | |
|---|---|---|---|---|---|---|---|
| | mean | sample | cons | sample | cons | interact | nobs |
| Knows Bazooka (yes=1)† | 0.82 | 0.26** | 0.06+ | 0.29** | 0.08 | 0.17** | 1538 |
| | (0.38) | (0.03) | (0.03) | (0.04) | (0.05) | (0.02) | |
| Number of improved varieties farmer knows | 2.66 | 0.40** | 0.42** | 0.48** | 0.50** | -0.16 | 1532 |
| | (1.50) | (0.12) | (0.12) | (0.16) | (0.16) | (0.24) | |
| Thinks improved variety is risky | 0.09 | 0.00 | 0.00 | 0.00 | 0.01 | -0.01 | 1447 |
| | (0.28) | (0.02) | (0.02) | (0.03) | (0.03) | (0.04) | |
| Thinks Bazooka is risky | 0.13 | 0.01 | -0.02 | 0.03 | 0.01 | -0.05 | 1207 |
| | (0.34) | (0.04) | (0.04) | (0.05) | (0.06) | (0.08) | |
| Recommended improved varieties to others | 0.59 | 0.29** | 0.02 | 0.29** | 0.02 | 0.01 | 1538 |
| | (0.49) | (0.04) | (0.04) | (0.06) | (0.05) | (0.07) | |
| Recommended Bazooka to others | 0.62 | 0.38** | 0.06 | 0.44** | 0.11 | -0.11 | 1260 |
| | (0.48) | (0.04) | (0.04) | (0.06) | (0.07) | (0.08) | |
| Will use improved varieties in the future | 0.83 | 0.05 | 0.01 | 0.05 | 0.01 | 0.00 | 1461 |
| | (0.38) | (0.03) | (0.03) | (0.05) | (0.05) | (0.07) | |
| Will use Bazooka in the future | 0.36 | 0.16** | 0.02 | 0.20** | 0.05 | -0.07 | 1503 |
| | (0.48) | (0.04) | (0.04) | (0.06) | (0.05) | (0.09) | |
| Index | 0.38 | 0.14** | 0.05+ | 0.16** | 0.07 | -0.03 | 1156 |
| | (0.36) | (0.03) | (0.03) | (0.05) | (0.05) | (0.06) | |

Note: Column (1) reports sample means at baseline and standard deviations below; columns (2)–(3) report differences between treatment and control groups estimated using the pooled model of Equation 2; (4)–(5) report differences between treatment and control groups estimated using the fully interacted model of Equation 1; column (6) is the interaction effect. Standard errors are below the estimates and are clustered at the level of randomization; **, *, and + denote significance at the 1, 5, and 10% levels based on sharpened q-values (Benjamini, Krieger, and Yekutieli, 2006). † indicates that baseline outcome was used as control in regression.

sumption traits of maize from improved seed varieties, we included a dedicated module in the questionnaire. This module asked farmers to compare maize from local varieties to maize from improved varieties (such as *Longe5* or *Bazooka*) across four specific traits: taste, portion size, appearance, and ease of cooking. For each trait, farmers rated their preference on a 5-point Likert scale, ranging from “local varieties are much better” to “local varieties are much worse.” For the purpose of our analysis, we consider improved varieties to be preferred when farmers indicate that local varieties are “somewhat worse” or “much worse” for a given trait.

Results are summarized in Table 7. The overall satisfaction with the consumption traits of improved varieties is high across the sample. Both the seed sample pack intervention and the cooking demonstration and blind tasting sessions significantly increased the proportion of farmers who perceive improved varieties as superior to local varieties according to the summary index, as well as across all four consumption attributes. Interestingly, the results show that the seed trial pack is equally, if not more, effective in changing biased perceptions. This suggests that trial pack interventions may, in some cases, also be sufficient to encourage farmers to learn about the consumption traits of new varieties, and strategies based especially on consumption attributes may not be necessary.

#### 5.2.2 Perceptions of Production Traits

The seed sample pack is primarily designed to address preconceived notions farmers may have about the production-related traits of improved varieties. For example, qualitative fieldwork conducted during the study’s preparation revealed that some farmers believe that improved seed varieties might offer higher yields but were less resistant to fall armyworm (*Spodoptera frugiperda*) infestations. Others, having been disappointed in the past, might no longer believe in the yield advantages of improved varieties (Miehe et al., 2023b). Providing free seed sample packs can be an effective way to alter these perceptions, as it allows farmers to directly experience the production traits of new technology on their own fields (Foster and Rosenzweig, 1995).

To test if our interventions alter perceptions of production traits of maize of improved varieties, we also include a module in the questionnaire where we ask farmers to compare seed of an improved variety to local seed on five production traits—yield, abiotic stress resistance such as drought or heat resistance, biotic stress resistance such as pests and weed resistance, time to maturity, and germination rates[13].

Results are summarized in Table 7. When farmers compare improved varieties directly to local varieties, the summary index indicates a significant positive impact from the seed sample pack. Farmers who received the seed sample pack updated their beliefs most notably regarding germination rates. Although the effects on the other production attributes are positive, the statistical power may

[13] Germination rate is actually more related to the quality of the seed rather than the variety being used; however, farmers may not understand this distinction in practice.

Table 7: Impact on Consumption traits - improved varieties compared to local

| | | *Pooled model* | | *Interacted model* | | | |
|---|---|---|---|---|---|---|---|
| | mean | sample | cons | sample | cons | interact | nobs |
| Taste | 0.70 | 0.21** | 0.09** | 0.27** | 0.15* | -0.11+ | 1424 |
| | (0.46) | (0.04) | (0.04) | (0.06) | (0.06) | (0.08) | |
| Portions | 0.81 | 0.10** | 0.10** | 0.14** | 0.15** | -0.08+ | 1360 |
| | (0.40) | (0.03) | (0.03) | (0.04) | (0.05) | (0.06) | |
| Appearance | 0.85 | 0.05* | 0.09** | 0.06 | 0.10* | -0.02 | 1421 |
| | (0.36) | (0.03) | (0.03) | (0.05) | (0.04) | (0.05) | |
| Ease of cooking | 0.71 | 0.14** | 0.13** | 0.19** | 0.18* | -0.10 | 1316 |
| | (0.45) | (0.04) | (0.04) | (0.06) | (0.06) | (0.08) | |
| Index | 0.32 | 0.23** | 0.20** | 0.29** | 0.26** | -0.12 | 1248 |
| | (0.60) | (0.05) | (0.05) | (0.09) | (0.09) | (0.11) | |

Note: Column (1) reports sample means at baseline and standard deviations below; columns (2)–(3) report differences between treatment and control groups estimated using the pooled model of Equation 2; (4)–(5) report differences between treatment and control groups estimated using the fully interacted model of Equation 1; column (6) is the interaction effect. Standard errors are below the estimates and are clustered at the level of randomization; **, *, and + denote significance at the 1, 5, and 10% levels based on sharpened q-values (Benjamini, Krieger, and Yekutieli, 2006).

be limited due to already high baseline perceptions of 10 varieties. No significant impact was observed from the cooking demonstration and tasting session, which aligns with expectations.

### 5.3 Decisions to Recycle Seeds

There are various reasons why farmers may recycle seed instead of purchasing fresh seed. For instance, it could be that farmers are unaware that there is a yield penalty from recycling hybrid seed. Alternatively, farmers may be hesitant to purchase new seeds, due to high costs or lack of trust in seed suppliers (Miehe et al., 2023a; Barriga and Fiala, 2020; Bold et al., 2017).

When we presented our finding to farmers during focus group discussions, the general impression was that farmers are typically aware of the yield penalty of recycling and that seed was also available, but some level of recycling is a rational response given that the yield reduction is gradual—the yield penalty increases the more times the same seed is recycled. Our data suggests that planting fresh *Bazooka* seed leads to an average yield of about 535 kilograms of maize per acre. In the subset of farmers that use local seed (but excluding recycled *Bazooka*), average yield is only 323 kilograms of maize per acre. In the subset of farmers that recycled *Bazooka* from the seed trial pack, average yield is 375 kilograms per acre. To plant one acre with *Bazooka*, one needs about 8 kilograms. As one kilogram of Bazooka costs UGX12,000, the cost of one acre of *Bazooka* maize is UGX96,000. We further assume that the cost of local seed, as well a recycling *Bazooka*, is negligible.

Figure 2 plots out profits as a function of the value of the harvest (proxied by the price at which a 100 kg bag of maize is sold). The graph shows that profits from recycling *Bazooka* for one season are generally higher than using fresh *Bazooka*. Only when prices at which *Bazooka* is sold exceed about UGX62,000 per bag does buying fresh *Bazooka* becomes more profitable than recycling. In our sample, the median sales price is UGX60,000 per bag, meaning that recycling the trial pack for one season would be a rational response.[14]

## 6 Conclusion

In this study, we conduct a field experiment to evaluate the effectiveness of two interventions aimed at increasing the adoption of improved maize seed varieties among smallholder farmers in eastern Uganda. The first intervention provides free seed sample packs, allowing farmers to assess production-related attributes of the improved variety, including its yield potential, pest tolerance, and germination rate. The second intervention consists of a cooking demonstration and blind tasting session designed to emphasize the consumption-related attributes

[14]Consistent with this, we also find that within the subsample of farmers that received the seed trial pack, farmers that report to have been selling maize at prices higher than UGX62,000 are significantly more likely to use fresh *Bazooka* seed as opposed to farmers that sold at low prices.

Table 8: Impact on Production traits - improved varieties compared to local

| | | *Pooled model* | | *Interacted model* | | | |
|---|---|---|---|---|---|---|---|
| | mean | sample | cons | sample | cons | interact | nobs |
| Yield | 0.92 | 0.03 | 0.00 | 0.03 | 0.01 | -0.02 | 1464 |
| | (0.27) | (0.02) | (0.02) | (0.03) | (0.03) | (0.04) | |
| Abiotic stresses | 0.72 | 0.06 | -0.03 | 0.10 | 0.00 | -0.06 | 1336 |
| | (0.45) | (0.04) | (0.04) | (0.05) | (0.06) | (0.08) | |
| Biotic stresses | 0.58 | 0.09 | -0.01 | 0.12 | 0.02 | -0.05 | 1391 |
| | (0.49) | (0.04) | (0.04) | (0.06) | (0.06) | (0.09) | |
| Time to maturity | 0.93 | 0.01 | 0.00 | -0.01 | -0.02 | 0.05 | 1446 |
| | (0.25) | (0.02) | (0.02) | (0.03) | (0.02) | (0.04) | |
| Germination Rate | 0.84 | $0.08^{+}$ | 0.05 | 0.09 | 0.06 | -0.02 | 1439 |
| | (0.36) | (0.03) | (0.03) | (0.05) | (0.04) | (0.06) | |
| Index | 0.10 | $0.11^{*}$ | 0.03 | $0.13^{+}$ | 0.05 | -0.04 | 1273 |
| | (0.58) | (0.05) | (0.05) | (0.08) | (0.07) | (0.10) | |

Note: Column (1) reports sample means at baseline and standard deviations below; columns (2)–(3) report differences between treatment and control groups estimated using the pooled model of Equation 2; (4)–(5) report differences between treatment and control groups estimated using the fully interacted model of Equation 1; column (6) is the interaction effect. Standard errors are below the estimates and are clustered at the level of randomization; **, *, and + denote significance at the 1, 5, and 10% levels based on sharpened q-values (Benjamini, Krieger, and Yekutieli, 2006).

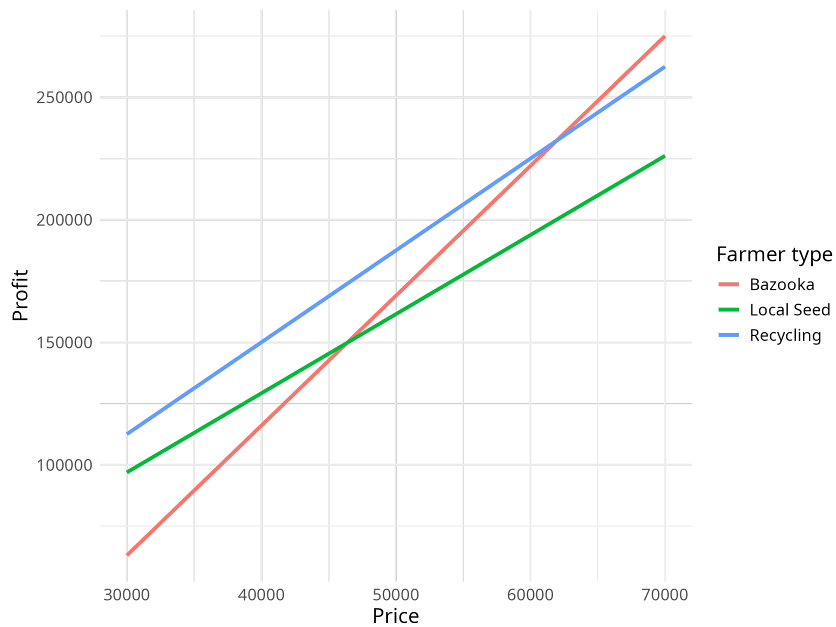


Figure 2: Profits as a Function of Sales Price

of the improved variety, such as taste, texture, and color of the food produced from the variety.

The interventions are tested using a cluster randomized control trial involving 1,560 maize farmers. The trial is clustered at the village level, with 10 households randomly selected from each village, and villages are assigned to treatments according to a 2x2 factorial design.

Our findings indicate that the seed sample pack intervention has an unintended effect: it reduces the likelihood that farmers adopt quality seed of improved varieties in the subsequent season. This counterintuitive result arises because farmers who received the sample pack are more inclined to recycle the seed from the sample pack, rather than purchasing fresh seed, and recycled seed from the sample pack is not categorized as "improved" in our analysis, given the widely accepted recommendation against reusing seed of hybrid varieties. The cooking demonstration and tasting session have little impact overall, though we do see a small increase in the probability that a farmer plants *Bazooka* as a result of this treatment.

Despite the unexpected outcome concerning seed adoption, the intermediary variables align with our expectations and indicate that the interventions achieved their intended effects. Specifically, the seed sample pack improves perceptions of production-related traits, while the cooking demonstration and tasting session enhance perceptions of consumption traits. What is more, the seed sample pack intervention also positively influences perceptions of consumption-related traits, in addition to production traits.

The main lesson we draw from this research is that consumption traits of varieties likely do matter to farmers and may be a contributing factor in the decision to adopt new varieties. However, interventions that explicitly highlight consumption traits may not be necessary; farmers notice differences in consumption attributes simply based on their experience growing and consuming sample packs. In that sense, a standard sample pack intervention may be most effective, as it allows farmers to learn about both consumption and production traits. Our findings also highlight the complex decision-making processes that farmers navigate when adopting improved seed varieties. While the seed sample pack intervention successfully increased farmers' awareness and appreciation of the improved variety's production and consumption traits, its unintended consequence—encouraging seed recycling—suggests that adoption is influenced not only by knowledge but also by heterogeneous benefits and costs of the technologies (Suri, 2011). Depending on the the yield decline from recycling and accessible maize prices that a given farmer faces, recycling once may be a cost-effective strategy. This seems to be the case for the average farmer in our sample. Hence, future interventions that provide farmers with free seeds should be cognizant of the possibility of recycling.

This result underscores the need for complementary interventions that address economic constraints alongside knowledge dissemination interventions (seed sample packs and cooking demonstrations and tasting sessions), such as policies that improve farmers' access to reliable and affordable seed, potentially through credit provision. Additionally, interventions that enhance market linkages and ensure that quality maize fetches premium prices may help shift the cost-benefit calculation in favor of purchasing fresh seed. Future research should explore these avenues to design more effective strategies for improving seed adoption and enhancing smallholder productivity in a sustainable manner.

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# References


Akwango-Aliau, D., G. Lukwago, R. M. Ariong, I. Kiyingi, I. Obongo, S. Adur, S. Angundubo, J. Ndhokero, H. Luzinda, T. Akongo, D. Magala, S. Mutonyi, G. Bwanika, A. Bua, Y. Baguma, and A. Agona. 2022. "Impact of NARO Bean and Maize Technologies on Farmer Livelihoods Contribution to Uganda's Economy." *National Agricultural Research Organisation* .

Anderson, M. L. 2008. "Multiple Inference and Gender Differences in the Effects of Early Intervention: A Reevaluation of the Abecedarian, Perry Preschool, and Early Training Projects." *Journal of the American Statistical Association* 103 (484): 1481–1495.

Barriga, A. and N. Fiala. 2020. "The supply chain for seed in Uganda: Where does it go wrong?" *World Development* 130: 104928.

Bellon, M. R., B. H. Kotu, C. Azzarri, and F. Caracciolo. 2020. "To diversify or not to diversify, that is the question. Pursuing agricultural development for smallholder farmers in marginal areas of Ghana." *World Development* 125: 104682.

Benjamini, Y., A. M. Krieger, and D. Yekutieli. 2006. "Adaptive linear step-up procedures that control the false discovery rate." *Biometrika* 93 (3): 491–507.

Biedny, C., N. M. Mason, S. S. Snapp, A. Nord, J.-C. Rubyogo, and J. Lwehabura. 2020. "Demonstration plots, seed trial packs, bidirectional learning, and modern input sales: Evidence from a field experiment in Tanzania." .

Birol, E., J. Meenakshi, A. Oparinde, S. Perez, and K. Tomlins. 2015. "Developing country consumers' acceptance of biofortified foods: a synthesis." *Food Security* 7: 555–568.

Blackie, M. and C. K. Mann. 2005. "The origin and concept of the Starter Pack." In "Starter packs: a strategy to fight hunger in developing countries? Lessons from the Malawi experience 1998-2003," 15–27. CABI Publishing Wallingford UK.

Bold, T., K. C. Kaizzi, J. Svensson, and D. Yanagizawa-Drott. 2017. "Lemon technologies and adoption: measurement, theory and evidence from agricultural markets in Uganda." *The Quarterly Journal of Economics* 132 (3): 1055–1100.

Boucher, S. R., M. R. Carter, J. E. Flatnes, T. J. Lybbert, J. G. Malacarne, P. P. Marenya, and L. A. Paul. 2024. "Bundling Genetic and Financial Technologies for More Resilient and Productive Small-Scale Farmers in Africa." *The Economic Journal* 134 (662): 2321–2350.

Carletto, C., P. Corral, and A. Guelfi. 2017. "Agricultural commercialization and nutrition revisited: Empirical evidence from three African countries." *Food policy* 67: 106–118.

Coates, J., A. Swindale, and P. Bilinsky. 2007. “Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide: version 3.” .

Conley, T. G. and C. R. Udry. 2010. “Learning about a New Technology: Pineapple in Ghana.” *American Economic Review* 100 (1): 35–69.

Cromwell, E. 1990. “Seed diffusion mechanisms in small farmer communities: Lessons from Asia, Africa and Latin America.” .

De Brauw, A., P. Eozenou, D. O. Gilligan, C. Hotz, N. Kumar, and J. Meenakshi. 2018. “Biofortification, crop adoption and health information: impact pathways in Mozambique and Uganda.” *American Journal of Agricultural Economics* 100 (3): 906–930.

Emerick, K., A. de Janvry, E. Sadoulet, and M. H. Dar. 2016. “Technological Innovations, Downside Risk, and the Modernization of Agriculture.” *American Economic Review* 106 (6): 1537–61.

Evenson, R. E. and D. Gollin. 2003. “Assessing the impact of the Green Revolution, 1960 to 2000.” *science* 300 (5620): 758–762.

Foster, A. D. and M. R. Rosenzweig. 1995. “Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture.” *Journal of Political Economy* 103 (6): 1176–1209.

Imbens, G. W. and M. Kolesar. 2016. “Robust standard errors in small samples: Some practical advice.” *Review of Economics and Statistics* 98 (4): 701–712.

Jones, M., F. Kondylis, J. Loeser, and J. Magruder. 2022. “Factor market failures and the adoption of irrigation in rwanda.” *American Economic Review* 112 (7): 2316–2352.

Kramer, B. and C. Trachtman. 2024. “Gender dynamics in seed systems: an integrative review of seed promotion interventions in Africa.” *Food Security* 16 (1): 19–45.

LaFave, D. and D. Thomas. 2016. “Farms, families, and markets: New evidence on completeness of markets in agricultural settings.” *Econometrica* 84 (5): 1917–1960.

Lin, W. 2013. “Agnostic notes on regression adjustments to experimental data: Reexamining Freedman’s critique.” *The Annals of Applied Statistics* 7 (1): 295 – 318.

Miehe, C., R. Sparrow, D. Spielman, and B. Van Campenhout. 2023a. *The (perceived) quality of agricultural technology and its adoption: Experimental evidence from Uganda*. Intl Food Policy Res Inst.

Miehe, C., B. Van Campenhout, L. Nabwire, R. Sparrow, and D. J. Spielman. 2023b. *Miracle seeds: Biased expectations, complementary input use, and the dynamics of smallholder technology adoption.* Intl Food Policy Res Inst.

Morgan, S. N., N. M. Mason, and M. K. Maredia. 2020. "Lead-farmer extension and smallholder valuation of new agricultural technologies in Tanzania." *Food Policy* 97: 101955.

Muralidharan, K., M. Romero, and K. Wüthrich. 2023. "Factorial Designs, Model Selection, and (Incorrect) Inference in Randomized Experiments." *The Review of Economics and Statistics* 1–44.

Olney, D. K., A. Pedehombga, M. T. Ruel, and A. Dillon. 2015. "A 2-year integrated agriculture and nutrition and health behavior change communication program targeted to women in Burkina Faso reduces anemia, wasting, and diarrhea in children 3–12.9 months of age at baseline: a cluster-randomized controlled trial." *The Journal of nutrition* 145 (6): 1317–1324.

Pícha, K., J. Navrátil, and R. Švec. 2018. "Preference to local food vs. Preference to "national" and regional food." *Journal of Food Products Marketing* 24 (2): 125–145.

Reicks, M., M. Kocher, and J. Reeder. 2018. "Impact of Cooking and Home Food Preparation Interventions Among Adults: A Systematic Review (2011–2016)." *Journal of Nutrition Education and Behavior* 50 (2): 148–172.e1.

Semalulu, O., P. Kibaya, S. Kyebogola, E. Mworozi, N. Sewankambo, and B. Gebru. 2022. "Profitability and Farmer Acceptability of Selected Climate Smart Technologies and Practices for Maize-Beans Production in Drought-Prone Areas, Uganda." *Agricultural Sciences* 13 (11): 1259–1284.

Singh, I., L. Squire, and J. Strauss. 1986. "A survey of agricultural household models: Recent findings and policy implications." *The World Bank Economic Review* 1 (1): 149–179.

Suri, T. 2011. "Selection and comparative advantage in technology adoption." *Econometrica* 79 (1): 159–209.

Tilman, D., C. Balzer, J. Hill, and B. L. Befort. 2011. "Global food demand and the sustainable intensification of agriculture." *Proceedings of the national academy of sciences* 108 (50): 20260–20264.

Timu, A. G., R. Mulwa, J. Okello, and M. Kamau. 2014. "The role of varietal attributes on adoption of improved seed varieties: the case of sorghum in Kenya." *Agriculture & Food Security* 3: 1–7.

Van Campenhout, B. 2021. "The role of information in agricultural technology adoption: Experimental evidence from rice farmers in Uganda." *Economic Development and Cultural Change* 69 (3): 1239–1272.