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Does improved storage technology promote modern input use and food security? Evidence from a randomized trial in Uganda

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ABSTRACT

We use panel data from a randomized controlled trial (RCT) administered among 1200 smallholders in Uganda to evaluate input use and food security impacts of an improved maize storage technology. After two seasons, households who received the technology were 10 percentage points more likely to plant hybrid maize varieties that are more susceptible to insect pests in storage than traditional lower-yielding varieties. Treated smallholders also stored maize for a longer period, reported a substantial drop in storage losses, and were less likely to use storage chemicals than untreated cohorts. Our results indicate that policies to promote soft kernel high-yielding hybrid maize varieties in sub-Saharan Africa should consider an improvement in post-harvest storage as a complementary intervention to increase adoption of these varieties.

1. Introduction

Many poverty alleviation and development programs implemented in sub-Saharan Africa (SSA) focus on increasing agricultural production and smallholder productivity, frequently by encouraging smallholders to increase their use of improved seed varieties and chemical fertilizer (Evenson and Gollin, 2003; Pingali, 2012). Often, however, these programs ignore what happens to output in the post-harvest season (World Bank, 2011). This is problematic, because while maize is the most important staple food in Eastern and Southern Africa, the softer kernel high-yielding hybrid varieties commonly promoted there offer less natural protection to insect attacks during storage compared with the lower-yielding traditional varieties that store relatively well (Golob, 2002; Smale et al., 1995). As a result, smallholders face a dilemma. Should they plant high-yielding varieties that carry storage risks or traditional varieties with lower yields, but less vulnerability to insect attacks during storage (Ricker-Gilbert and Jones, 2015)?

In this study, we use a randomized controlled trial (RCT) to measure whether a smallholder's ability to store maize using an improved storage technology affects the household's storage decision and, ultimately, its subsequent decisions about using modern inputs. In our RCT, we provided to a randomly selected group of households one Purdue Improved Crop Storage (PICS) hermetic (airtight) storage bag—an improved grain storage technology—that eliminates insect pests in storage when properly sealed. We compare choices and decisions among this treated group against a control group, consisting of farmers that received no intervention and continued to use traditional storage techniques. Because not all households who were randomly offered the technology chose to use it, we estimate intention-to-treat (ITT) effects for its policy relevance. Moreover, the impacts on treated households who took-up the offer and actually used the storage technology are likely to be larger. That is, unlike the local average treatment effects (LATE) on compliant households, the

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estimated ITT effects average impacts across both treated households who used the technology and those who did not.[1]

The present article has two main objectives. First, we estimate whether receipt of an improved storage technology leads to input-related behavioral changes in maize cultivation. The behavioral changes of interest include the uptake of improved maize varieties in terms of adoption and intensity (share of area planted to improved varieties), and, possibly, the use of inorganic fertilizer for increasing maize yields. Because improved maize varieties are more susceptible to pest attacks during storage due to their softer kernels and open husks relative to the traditional, lower-yielding varieties, farmers face an increased post-harvest storage risk when choosing to plant these improved varieties. Using panel data from Ethiopia, Dercon and Christiaensen (2011) showed that ex-post production risk (rainfall variability) reduces a household's adoption of improved inputs (inorganic fertilizer) ex-ante. If the same holds true in our context, when households have the ability to store improved maize varieties in an effective, chemical-free hermetic storage technology, their storage risks or storability concerns may be mitigated. Thus, access to hermetic storage technology may influence the cultivation of improved maize varieties.[2] Further evidence that storability concerns may negatively influence the adoption of improved maize varieties comes from Malawi (Katengeza et al., 2012; Lunduka et al., 2012), Zimbabwe (Derera et al., 2006), and Uganda (Obaa et al., 2005) where farmers expressed preference for traditional varieties due to storability concerns.

Our second objective is to explore some of the possible channels through which receipt of an improved storage technology may influence the adoption of improved maize varieties. For example, these include (i) the quantity of maize stored at harvest, (ii) the duration of time that maize is stored, and (iii) use of chemical insecticides, often referred to as storage chemicals, on stored maize. We also examine the impact of the technology on the percentage of self-reported post-harvest losses (PHL) indicated by households.[3] Previous studies show that hermetic storage technologies are effective at limiting maize damage in storage (De Groote et al., 2013; Njoroge et al., 2014; Tefera et al., 2011). Therefore, one might reasonably expect access to an improved storage method to influence storage decisions.

To our knowledge, few published findings explore the causal link between storage technology and inputs use among smallholder farmers in SSA. Furthermore, there has been little or no rigorous impact analysis thus far for hermetic storage bags in SSA, as discussed in a recent review of the topic (Sheahan and Barrett, 2017). With few exceptions, issues relating to post-harvest losses have not been considered in studies that evaluate the adoption of improved inputs such as seed and inorganic fertilizer among smallholder farm households. Thus, the relationships between post-harvest management practices, storability concerns, and adoption of improved seed varieties in SSA remain poorly understood. Understanding these relationships is important for future maize productivity and food security in the region (Bezu et al., 2014; Mason and Smale, 2013).

[1] For comparison, the local average treatment effect (LATE) estimates for main outcomes are shown later in this paper.

[2] Dercon and Christiaensen (2011) examined risk in production technologies and welfare consequences on households when shocks resulted in a poor harvest. The risk in our context occurs during storage but the decision-making process is the same for either (pre-harvest or post-harvest) production risk.

[3] One might ask why we did not examine impacts of our intervention on maize yields or output as one of the key impacts of our intervention. The reason is that yield or output is not a decision variable but rather an outcome variable, which is based on endogenous household decisions like seed, fertilizer and management decisions, along with exogenous factors like rainfall. Rainfall was low across Uganda in the season following our intervention, which also made it difficult for us to pick up a statistically significant impact of the hermetic bags on yields (see Appendix Table C.3 for the model of yields regressed on the hermetic bag treatment).

The present article makes two main contributions to the literature. First, we fill a policy research gap for SSA by estimating a causal relationship between improved storage technology and improved input adoption. Ricker-Gilbert and Jones (2015) examined this linkage using observational panel data from Malawi, and found the use of chemical insecticides to be significantly associated with the probability of adopting improved seed varieties. However, the authors stop short of concluding causal impact in their study, and advocate for the use of an RCT to answer the question more fully in the future. Our impact evaluation with experimental design complements and builds upon Ricker-Gilbert and Jones' (2015) study.

The majority of studies that have estimated the impacts of improved storage technologies in developing countries are observational. For instance, Gitonga et al. (2013) used propensity score matching (PSM) to evaluate the economic and food security impacts of hermetic metal silo on duration of maize storage, loss abatement, and spending on storage chemicals for maize-growing farmers in Kenya. In Central America, Bokusheva et al. (2012) used regression analysis and a Tobit model to estimate impacts of hermetic metal silo on adopter's well-being, sales of production, and the number of months a farmer purchased foods, respectively.

To our knowledge, our study is one of a very few to have evaluated improved storage technologies as part of an RCT. Ndegwa et al. (2016) used RCT to investigate the effectiveness of hermetic storage bags at reducing storage losses and its economic viability in an on-farm trial in one district of Kenya. Basu and Wong (2015) conducted an evaluation of a randomized seasonal food storage and food credit programs or treatments in West Timor Indonesia. They investigated whether access to improved storage technology helps households to transfer assets (staple food endowment) from harvest to lean season, smoothing inter-seasonal household consumption. They find that the storage treatment increased non-food consumption but had no effect on staple food consumption. In a more recent study, Aggarwal et al. (2017) experimentally evaluate a group-based grain storage scheme through savings clubs in Kenya. They find that individuals who joined the group-based savings clubs were more likely to store maize to be consumed or sold at least one month after harvest. Our study builds on this sparse literature by testing if there is a behavioral link on the part of smallholders between improved storage technology, storage decisions and input adoption decisions the next season.

Our second contribution is to use a large sample (nearly 1200 smallholders) surveyed over two years (2014 and 2016). The experimental panel dataset has a broad geographic scope that gives it a semblance of being nationally representative of maize producing households in Uganda. The broader geographic scope relative to previous studies that evaluate improved storage technologies confers a measure of external validity on our study to support the internal validity offered by our experimental design. As such, our results should be generalizable to similar populations elsewhere in SSA.

Results from our study indicate that households treated with the improved storage technology are 10 percentage points more likely to plant hybrid maize seed varieties the following year (significant with p-value$<$0.05), consistent with observational findings reported by Ricker-Gilbert and Jones (2015) in Malawi. Our findings have implications for improved maize variety adoption, maize productivity, and potentially, food security among smallholder households; because they suggest that, an improved storage technology can be a complementary intervention for promoting the adoption of improved maize varieties.

On the possible channels of impact, we find that the treated households who received the technology do not increase the quantity of maize stored at harvest, likely because maize is their staple crop so they adopt a safety-first mentality and used the improved hermetic bag in place of a traditional bag. However, treated households store maize with the intent of consuming it for three weeks longer (significant with p-value $<$0.01), and they store maize with the intention of selling it for one week longer (significant with p-value $<$0.10). In addition, treated households are less