Assessing the impacts of postharvest storage technology on household food security: Experimental evidence from Uganda

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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). Often, however, **these programs ignore what happens to output in the post-harvest season.** Because the softer kernel high-yielding hybrid varieties commonly promoted in the region offer less natural protection to storage insect attacks relative to the lower-yielding traditional varieties that store well, smallholder farm households face a **rational decision between high-yielding maize varieties that carry storage risk** vs. the low-yielding **traditional maize varieties that are less vulnerable to insect attacks during storage** (Ricker-Gilbert and Jones, 2015; Sheahan and Barrett, 2017).

Objective and Contribution

This study has two broad objectives:

- **To test** whether there is a **causal relationship** between **access to improved postharvest storage technology** and **improved inputs** (maize seed and fertilizer) use.
- **Explore** some **potential causal pathways** (storage decisions and postharvest losses reduction) through which access to improved storage technology may influence adoption of improved maize varieties provided there is a linkage from the first objective

We make three contributions to literature:

- We **fill a policy research gap** for SSA by estimating causal relationship between improved storage technology and improved input adoption and intensity.
- We use **randomized controlled trial (RCT)** to make causal inference. This is the first study to do so in a developing country context. RCT gives **internal validity** to our causal effects.
- We use a large sample (nearly 1,200 smallholders) **experimental panel data** with broad geographic scope that gives a semblance of being **nationally representative** of maize-producing households in Uganda. This confers **external validity** on our study and results should be generalizable to similar populations elsewhere.

Maize Production & Postharvest Storage

Maize yield is, on average, estimated at 1.5 MT/Ha. It remains low due to low uptake of improved varieties and inorganic fertilizer use. Moreover, **lack of access to improved storage technology** may prevent households from investing in high-yielding varieties due to storage risk (Dercon & Christiaensen, 2011).

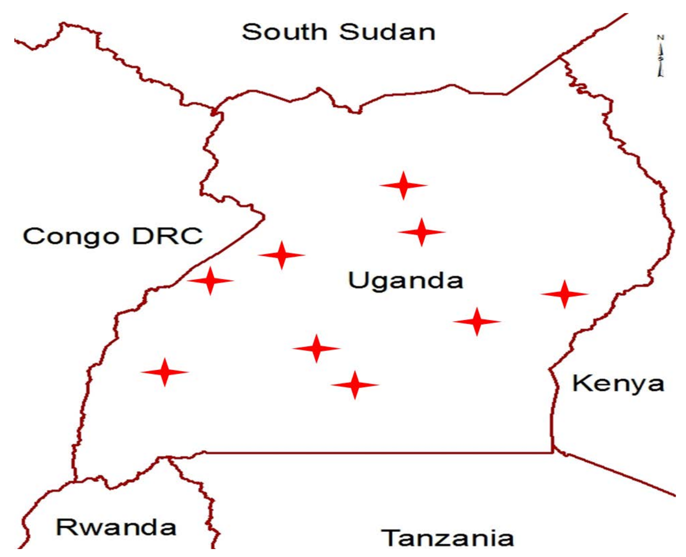
Distribution of storage technologies by smallholders at baseline

Storage Technologies	Season 1, 2014 (%)	Season 2, 2013 (%)	Sample Average (%)
Woven polypropylene bag	71.2	70.5	70.9
Heaped in House	10.7	10.7	10.7
Granaries	7.7	8.1	7.9
Private off-farm store	1.8	1.9	1.8
Open-air hanging	0.8	0.9	0.9
Hermetic (drum/silo/jerry can)	0.8	0.6	0.7
Metal silo/drum	0.2	0.2	0.2
Hermetic bags	0.1	0.2	0.1
Others	6.8	6.8	6.8
Observations	1,146	1,076	1,111

Source: Authors' compilation

Data and Sampling

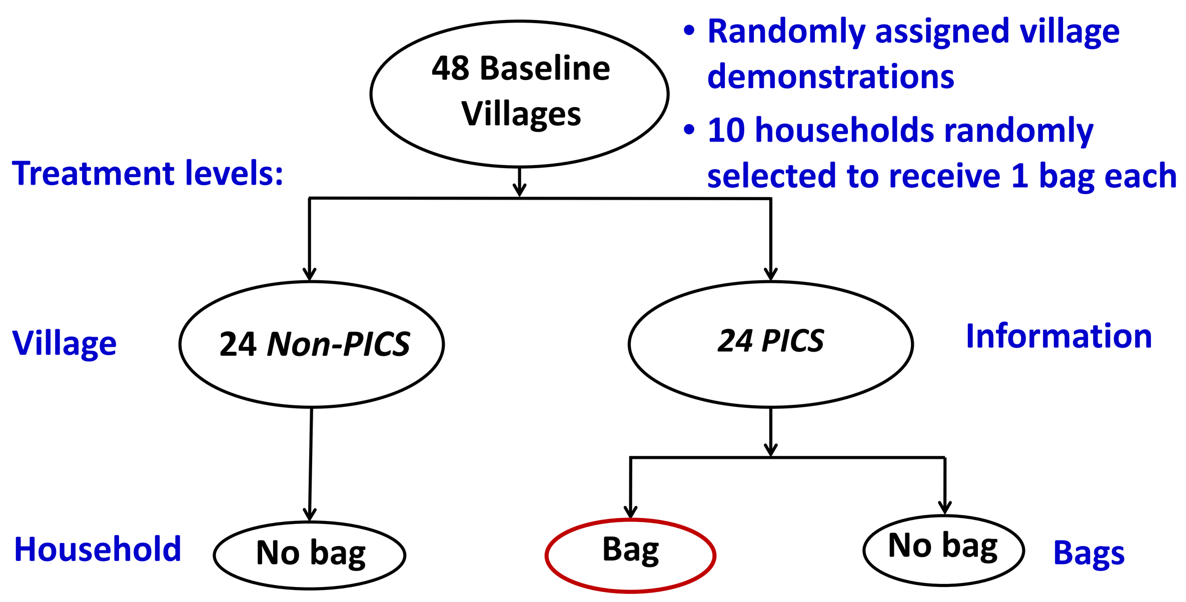
We use **a multi-level stratified sampling** approach.



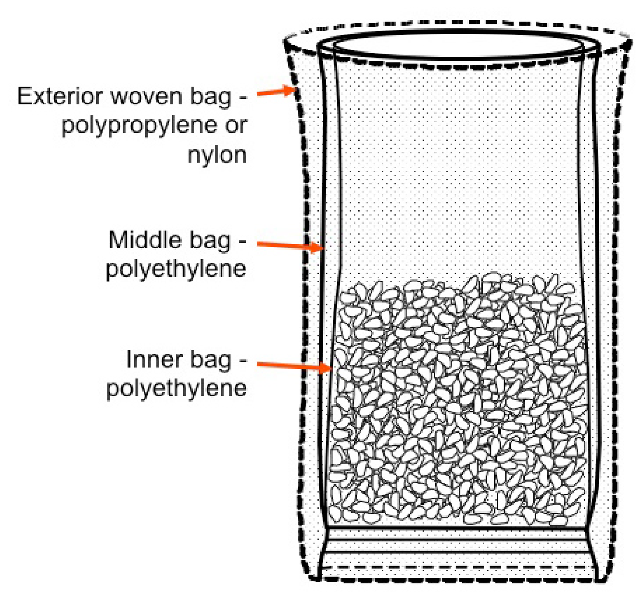
- **4 Regions**
- **9 Districts (in red)**
- **24 Sub-Counties**
- **48 Parishes**
- **48 Local council ones (LC1s)**
- **25 Households per LC1**
- **Approx. 1200 Random Households**

Baseline Survey (2014) → ***Intervention (2015)*** → ***Post-intervention survey (2016)***

Experimental Design



Treatment Intervention



Conceptual Framework

Assumption(s): (i) $q_h(I) > q_h(\boldsymbol{trad.})$; **(ii) PHL storability risk with** I

$$\pi = p_l q_l - rI - \omega T \qquad (1)$$

p, r & ω are prices of maize output, seed & storage technology, respectively

$$q_l = [1 - \alpha(T)] q_h(I) \qquad (2)$$

Also, h & l subscripts represent harvest and lean period, respectively; α, q, T & I represent expected storage loss (%), output, hermetic tech. and improved maize seed, respectively.

Substitute (2) into (1) and assume CD function. From FOCs w.r.t T & I, we can show that $\frac{\partial I}{\partial \alpha} < \mathbf{0}$ and $\frac{\partial \alpha}{\partial T} < \mathbf{0}$. Therefore, from the chain rule, access to improved postharvest technology should increase cultivation of high-yielding maize varieties (equation 3).

$$\frac{\partial I}{\partial T} = \frac{\partial I}{\partial \alpha} * \frac{\partial \alpha}{\partial T} > 0 \qquad (3)$$

Empirical Framework

- Not all treated households used the technology; but we focus on intention-to-treat **(ITT)** effects for its policy relevance. Binary indicator outcomes estimated via **LPM**
- Three estimators for robustness checks: simple mean difference (SMD), difference-in-difference (DiD), and fixed effects (FE) model.

SMD	$y_{ijr} = \lambda + \delta P_j + \tau_{SMD} P_j * T_i + \boldsymbol{\beta X_{ijr}} + \sigma_r + \varepsilon_{ijr}$	(4)
DiD	$y_{ijrt} = \lambda + \varphi T_i + \kappa S_t + \tau_{DiD} S_t * T_i + \boldsymbol{\beta X_{ijrt}} + \sigma_r + \varepsilon_{ijrt}$	(5)
FE	$y_{ijrt} = \lambda + \tau_{fe} T_i + \boldsymbol{\beta X_{ijrt}} + \theta_t + \mu_i + \varepsilon_{ijrt}$	(6)

y_{ijr} represents outcome variables for household i in LC1 j and region r; P_j, T_i, S_t & θ_t are binary indicator variables = 1 for treatment LC1 j, treated household i, observation is from panel wave2, and season, respectively; $\boldsymbol{X_{ijr}}$ is a vector of household covariates; σ_r, μ_i & ε_{ijr} are region indicators, time-invariant unobserved heterogeneity, and idiosyncratic error term, respectively. The **main parameter estimate is τ** and all other Greek letters are other parameter estimates.

Results

Baseline randomization balance checks:

Outcome Variables	Control		Treated	
	Mean	SD	Coeff.	p-val.
	(1)	(2)	(3)	(4)
=1 if HH planted improved maize seed	0.34	0.48	-0.03	0.40
Share of improved maize area (%)	34	47.20	-3.42	0.34
=1 if HH used inorganic fertilizer	0.09	0.29	0.02	0.40
Quantity stored (kg)	606	1024	32.20	0.74
Length of storage for consumption (weeks)	14.4	9.63	-0.73	0.52
Length of storage for sales (weeks)	4.4	6.08	-0.19	0.59
=1 if HH used storage chemical on maize	0.12	0.32	-0.03*	0.08
Self-reported postharvest losses (%)	3.15	5.99	0.481	0.37

Randomization is successful. No systematic difference between the treatment and control groups.

Main impacts:

Outcome variables	SMD	DiD	FE
=1 if HH planted improved maize variety	**0.08*** (0.039)	**0.10**** (0.048)	**0.10**** (0.045)
Share of improved maize area (%)	**7.05*** (3.668)	**10.25**** (4.727)	**10.29**** (4.727)
=1 if HH used inorganic fertilizer	-0.01 (0.028)	0.01 (0.035)	0.03 (0.036)

Robust standard errors, clustered at village level, are shown in parentheses. ***p<0.01, **p<0.05, *p<0.1

Indeed, access to **improved storage technology increases** the **adoption and intensity of high-yielding maize varieties** that are usually vulnerable to insect pest attacks in storage. No impact on inorganic fertilizer use.

Potential Causal Pathways:

Dependent variables	SMD	DiD	FE
Quantity stored (kg)	23 (32.67)	-70 (69.90)	-80 (61.99)
Length of storage for consumption (weeks)	**1.64**** (0.65)	**3.01***** (0.77)	**3.00***** (0.78)
Length of storage for sales (weeks)	0.61 (0.44)	**0.62*** (0.37)	**0.69*** (0.35)
=1 if HH used storage chemical on maize	**-0.07***** (0.02)	**-0.04***** (0.01)	**-0.04**** (0.02)
Self-reported postharvest losses (%)	**-2.35***** (0.59))	**-2.4**** (0.94)	**-3.34***** (0.87)

Robust standard errors, clustered at village level, are shown in parentheses.
***p<0.01, **p<0.05, *p<0.1

Conclusions and Policy Implications

We used a randomized controlled trial to investigate the impacts of improved technology on smallholder households' decisions to adopt high-yielding maize varieties. Our results indicate that:

- **Causal linkage exist** between **postharvest technology and improved** (high-yielding) **maize varieties adoption.**
- Access to hermetic storage bags:
  - **Increased** the **adoption and intensity** of improved maize varieties **by 10 percentage points**
  - **Increased duration of stored maize** for consumption **by 20 percent**
  - **Reduced total storage loss by 67 to 90 percent**

We recommend that development agencies, researchers and policy makers promoting improved seeds in SSA should consider postharvest storage as a complementary intervention.

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PICS3 Purdue Improved Crop Storage

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