

**ONE ACRE FUND**

**Post-Harvest Home Storage**

*2014 Trial Report*



*Hailey Tucker/One Acre Fund.*

## Farmers First

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### **Background**

Closing the yield gap for smallholder farmers is a function of many things, including agricultural inputs and production techniques. However, increasing yields for smallholder farmers is only part of the solution to increasing food security. Substantial post-harvest loss can occur when grain is harvested at the wrong time, improperly dried, damaged during handling, or infected by pests or fungi. Farmers also benefit from post-harvest storage technologies as it allows them to store the harvest and sell grain when prices are high, often several months after the crop was harvested.

### **I. Results Summary**

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- **Primary product configurations tested:** Effective post-harvest home storage requires a holistic approach. One Acre Fund evaluated several post-harvest storage technologies in 2014 including the PICS home storage bag to maintain high grain quality and a home storage loan that allows farmers to overcome the physical and financial barriers to delayed grain sales. In support, One Acre Fund is already offering Actellic Super, a storage pesticide, at scale.
- **Current storage practices:** In the absence of improved home storage technologies, farmers use a variety of local practices. Some farmers will not treat their grains at all, while other farmers will use chemical or natural insecticides like ash or hot chili to deter pests. Farmers may also store their grain above the cooking space, using the cooking smoke to keep pests out of the grain. The current One Acre Fund home storage package offers Actellic Super storage pesticide and the PICS hermetic storage bag.
- **Potential value of intervention:** Post-harvest home storage interventions positively impact farmers in a number of different ways: PICS bags can lead to lower pesticides usage, higher quality and quantity of stored grain, and access to higher market prices. A home storage loan lets farmers meet consumption needs and access higher market prices for their grain. Actellic Super, a low cost storage pesticide, is very popular and will reduce the post-harvest losses of over 100,000 One Acre Fund farmers in Kenya in 2015. The profit impact for these products ranges from \$6 to \$13.
- **2015 trials:** One Acre Fund is planning to trial:
  - Strategies to improve compliance with the home storage loan.
  - Plastic tarps to make it easier for farmers to dry their grain to achieve correct moisture content.

### **II. Product Rationale and Approach**

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- **Rationale:** Post-harvest losses total 10 to 20 percent of harvests in sub-Saharan Africa.<sup>i</sup> For smallholder farmers, the lost yield can dramatically stifle household expenditure and consumption decisions. Home storage products, like hermetically sealed bags or pest control tools, enable farmers to reduce loss and increase stored grain quality.
- **Our approach:** One Acre Fund seeks to identify and scale technologies that are low-cost, easy to adopt, and have a high financial impact for households.

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- **Product selection criteria:** The trial configurations were chosen based on the four criteria of 1. Impact (incremental dollar income added to the farmer), 2. Adoption (farmer demand), 3. Complexity (ability to realize return) and, 4. Operability (scale potential). We are also mindful of the long-term health impacts of storage pesticides and the potential market price distortions attributable to storage loans and delayed grain sales.

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### III. Partners Consulted

Post-harvest home storage is a multi-faceted issue. We solicited the advice of experts around the world to ensure only the highest quality products would be trialed:

- **Purdue University** – Purdue University produces the PICS (Purdue University Improved Cowpea Storage) bag. University staff offered guidance on proper use and maintenance of the bags.
- **Michael Jones** – University of Florida Masters student and Fulbright researcher studying storage technology in East Africa. Mr. Jones provided valuable context and guidance.
- **Rwanda Agricultural Board** – The Rwanda Agricultural Board ran trials with a competing product on behalf of the Rwandan coffee industry. Their trial findings provided important results.
- **Ministry of Agriculture and Rwanda Environmental Management Agency** – These government agencies supported distribution of PICS due to its positive environmental impact despite the nation-wide plastic bag ban.
- **Institut National de la Recherche Agronomique du Niger (INRAN)** – INRAN conducted evaluations stress testing the PICS bag.

These organizations and individuals were extremely helpful, and were excited to see their research and products being put into farmers' hands.

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### IV. Trials Summary (Phases 0-4)

One Acre Fund tested home post-harvest storage with a standardized trial phase process as summarized below.

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	Trial Phase				
	0	1	2	3	4
<b># Farmers</b>	0	0	231	1,587	106,865 <sup>1</sup>
<b>Storage Impact</b>	N/A	96% infestation reduction	+70% more grain sold	+20% more grain stored	N/A
<b>Profit Impact</b>	N/A	N/A	+\$13	+\$6	N/A
<b>Adoption Level</b>	N/A	N/A	90%	59-69%	57% <sup>2</sup>
<b>Key Activities / Configurations</b>	<b>Preliminary Research</b> 1. Desk research 2. Consultation with experts	<b>Research station trials:</b> 1. On-station storage trials	<b>Farmer level trials:</b> 1. PICS impact evaluation	<b>2015 district offering:</b> 1. Maize storage loan	<b>Full Scale offering:</b> 1. Actellic Super
<b>Testing Priorities</b>	<ul style="list-style-type: none"> <li>Research potential easy, high impact post-harvest home storage technologies.</li> </ul>	<ul style="list-style-type: none"> <li>Under controlled conditions, understand the potential impact achievable with new storage technologies.</li> </ul>	<ul style="list-style-type: none"> <li>Evaluate impact, complexity, and operability at a larger scale of promising new home storage technologies.</li> </ul>	<ul style="list-style-type: none"> <li>Measure impact and determine demand for improved home storage products through purchase rates at the district level.</li> </ul>	<ul style="list-style-type: none"> <li>Continue monitoring adoption levels and impact.</li> </ul>

The below table outlines the post-harvest storage trials.

<sup>1</sup> Farmers in 2015 who requested Actellic Super from One Acre Fund.

<sup>2</sup> This figure is the percent of farmers who requested Actellic Super as part of their LR 2015 package in Kenya.

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Trial Name	Hypothesis	Treatments	Controls
<b>PICS Storage Bag</b>	Improved storage bag technology reduces the need for pesticide use while minimizing grain loss due to pests. PICS storage bags are easily adopted, as they require minimal additional training.	Farmers received PICS storage bag and training	Farmers that did not receive a PICS storage bag and used local storage practices
<b>Maize Storage Loan</b>	Due to credit constraints, farmers often sell their maize when market prices are low. A storage loan provided at harvest allows farmers to address immediate spending needs, then sell their grain for a higher price later in the season.	Treatment 1: Farmers that received the storage loan following harvest Treatment 2: Farmers that received the loan three months after the harvest	635 One Acre Fund farmers
<b>Actellic Super Dust</b>	Actellic storage dust kills pests in grain and prevents further infestation, maintaining a higher quantity and quality of marketable grain.	50 g Actellic Super per 90 kg of maize	Traditional storage practices

V. Results

**PICS Improved Storage Bags: Trial Overview**

**Hypothesis**

Improved PICS storage bags protect farmers’ harvest by hermetically sealing the grain, cutting off the oxygen supply to pests that would otherwise damage it. By using an improved storage bag, farmers can keep a higher quantity of higher quality grain while reducing pesticide use. The ability to store grain safely for longer will let farmers delay the sale of their harvest and access a higher price.



*One Acre Fund field officer demonstrates how to seal PICS bag. Hailey Tucker/ One Acre Fund.*

**Design**

One Acre Fund evaluated PICS storage bag technology with 231 farmers in two districts in Rwanda during the 2013 A and B growing seasons. Farmers were first asked if they wished to receive the PICS storage bag. Farmers that expressed interest were randomly assigned to the treatment group that

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received the opportunity to buy the PICS bag and a control group who did not receive that opportunity. One Acre Fund then tracked farmer uses of the bag for 44 weeks from February to December 2013 monitoring grain purchases, sales, consumption, and other transactions. Data were collected for both maize and beans.

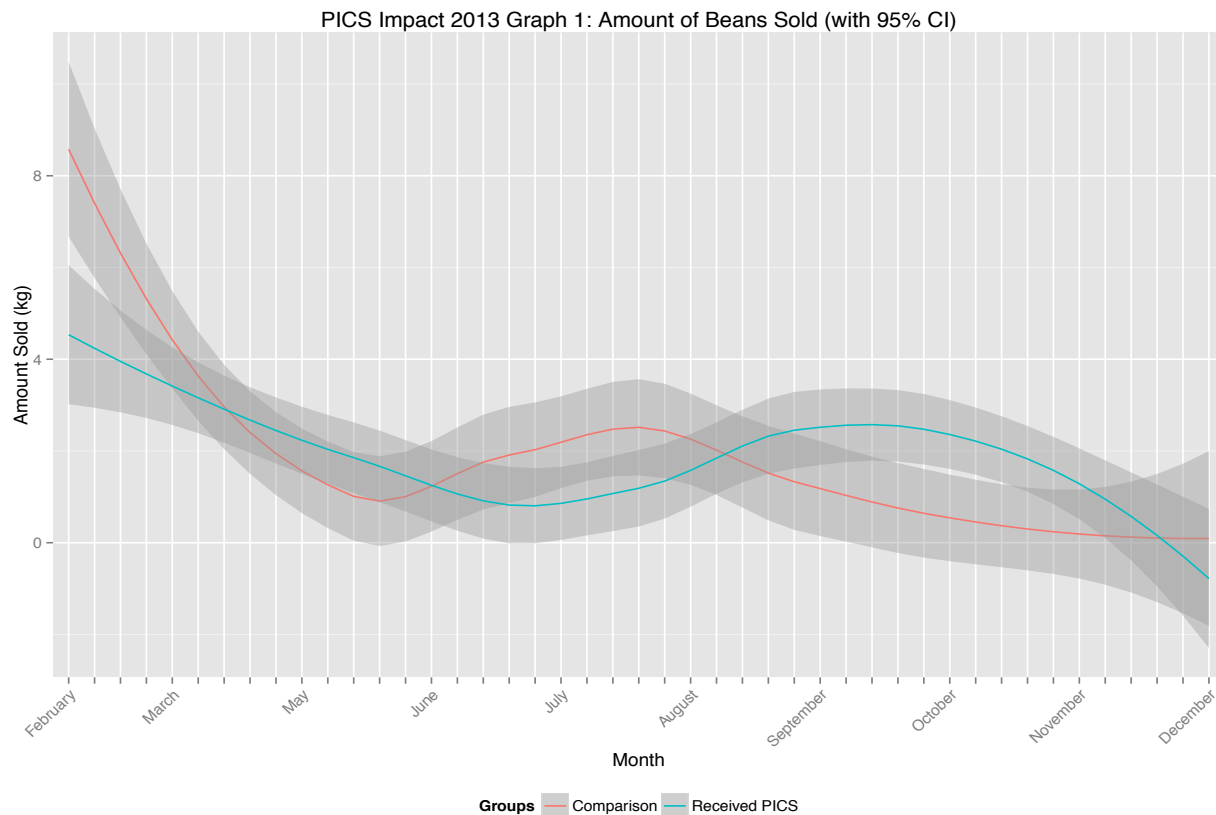
### Impact

One Acre Fund found that farmers who received the PICS bag saw positive increases in the total amount of beans sold and in total earnings from bean sales. These findings were significant at the five percent and ten percent levels respectively. The data clearly supported the hypothesis that farmers were able to sell more beans and delay their bean sales. However, the findings do not conclusively prove that farmers with PICS were able to access higher prices.

Trial	Configuration	Location/Date	Grain Sales (kg)	Profit/farmer	Profit Change vs. Trial Control
<b>1. Control:</b> One Acre Fund farmers who did not receive the PICS bag	118 farmers	Western and Eastern Rwanda, 2013	41	\$19	\$0
<b>2. PICS:</b> One Acre Fund farmers who received the PICS bag	113 farmers	Western and Eastern Rwanda, 2013	69	\$32	+\$13

The graph below shows bean sales over the study period. The red line represents the control group bean sales while the blue line represents the treatment group bean sales. The treatment group is able to delay bean sales following harvest and then, later in the season, increase their sales at a period when control farmers' sales decrease.

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### Adoptability

**Cost:** PICS bags cost \$3 USD per bag. In the study, farmers purchased approximately 1.5 bags on average.<sup>ii</sup> Farmers report price as the biggest deterrent to adoption. In the 2014 B season, 31 percent of farmers purchased a PICS bag during an adoption trial in Rwanda.<sup>iii</sup> In that season, distribution was limited to eastern districts in Rwanda as post-harvest losses are more pervasive due to hotter environment. Rolling 2015B season adoption numbers show adoption at 16 percent, with 15 percent of contracts on record. Although the final farmer list has not been set, an adoption rate of 16 percent would equate to roughly 14,400 farmers.

**Complexity:** Farmers must be instructed to seal the bag tightly and seal it every time they open it. While this practice alone is not complicated, small errors can lead to oxygen entering the bag and diminishing the effectiveness of the technology. While not a constraint in terms of adoption, this is an important point of training vigilance for the field teams and trainers.

**Preference:** Among farmers who adopted PICS in Rwanda, 71 percent like the bag because it means they don't have to use insecticides. Only six percent of adopting farmers say they like PICS because it allows them to store for longer.

### Operability

**Sourcing:** Plastic bags are banned in Rwanda. However, the Rwanda Environmental Management Agency (REMA), in coordination with the Rwandan Ministry of Agriculture, permits One Acre Fund to

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source and produce the bags locally due to the bag's displacement of insecticides and positive impact on farmers. One Acre Fund purchases the bag for \$2 from a company that produces the bags locally.

**Distribution:** The primary concern is the possibility of ripping a bag. PICS bags come in 50 bag bundles that can possibly snag and tear during transport in trucks. Field officers and farmers inspect the bags at distribution and if farmers find a hole, the bag is replaced. Overall, however, One Acre Fund expects less than one percent of bags to have issues. PICS bags are currently only distributed at the start of the B season for farmers to store their A season harvest, the larger of the two harvests.

**Training Complexity:** One Acre Fund structures trainings to give farmers hands-on experience with new technology. Field officers demonstrate how to fill and close the bag properly, and allow farmers to practice as well. This is a small source of logistical complexity, as the field officer needs materials available, either grain or clothes, to stuff into the bag in order to properly demonstrate how to close it. However, this training format does not constitute an obstacle to offering PICS at scale.

### Next Steps

- One Acre Fund plans to roll out PICS bags to all districts in Rwanda in the 2015 B season.

## Maize Storage Loan: Trial Overview

### Hypothesis

Farmers sell their harvest immediately following harvest, despite the low prices, because they are cash constrained. Offering farmers credit following harvest will allow them to address immediate household spending needs and delay selling their harvest for several months. This in turn allows them to access higher prices and increase farm profits.

### Design

In collaboration with a graduate student from The University of California, Berkeley, One Acre Fund ran a large-scale trial to assess the impact of post-harvest credit on farmer behavior and market prices. Farmers that participated in the trial were randomized along two major criteria: the number of loan clients in a village (loan client density) and when farmers received their loan (loan delivery timing).

The purpose of the two-tiered randomization was to answer three key hypotheses:

- Hypothesis 1: Receiving a storage loan will allow farmers to store more for longer periods of time, access better prices at market, and earn more profit.



*Farmer displays tag marking maize for longer-term storage. Hailey Tucker/One Acre Fund.*



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- Hypothesis 2: Loans will have different effects in villages in which many farmers take the loan, versus villages in which few farmers take the loan. Namely, loans in high-density villages will see maize taken off the market following harvest, leading to higher prices. In low-density villages, prices will follow a more traditional seasonal price curve.
- Hypothesis 3: Credit delivered at time of harvest will allow farmers to fully delay the sale of their grain. Credit delivered several months after harvest will be less effective in maximizing returns on stored grain.

### Impact

The study found that:

1. **Loans let farmers access better prices.** Farmers who received the loan were freed to take advantage of the anticipated change in prices. Farmers that received the loan put more maize in storage and sold maize at a higher price later in the season. Farmers that received the loan had higher revenues than farmers without the loans, but this difference was not significant. In short, the loan helps farmers benefit from seasonal price fluctuations.
2. **The number of loan clients negatively affects benefit.** In villages where more households received the loan, market prices did not fluctuate throughout the season. This can be attributed to more maize being taken off the market (stored in households), allowing prices to rise at harvest due to temporarily lower supply. Conversely, farmers in low loan-client-density villages were more able to capitalize on predicted seasonal price changes. As One Acre Fund moves toward its goal of increasing client density per site, the evidence suggests that the maize storage loan will be less effective for farmers. One Acre Fund will need to consider modifying the loan, or only offering it in lower client density areas.
3. **Receiving the loan at harvest time is best.** The study examined the impact on farmers of receiving the loan shortly after harvest in October or several months later in January. As seen in the table below, receiving the loan at or close to harvest significantly changes the impact story. Farmers who received the loan in October stored more maize and were able to benefit from higher prices. This suggests it is best to extend the maize storage loan to farmers at harvest time to maximize farmers' opportunity to benefit from the credit.

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### Loan Timing Test:

Trial	Configuration	Location / Date	Amount Stored (kg)	Profit/farmer	Profit Change vs. Trial Control
<b>1. Control:</b> Did not receive storage loan	635 farmers	Western Kenya, LR 2013	273	\$6	N/A
<b>2. Early loan delivery:</b> Received storage loan in October	474 farmers	Western Kenya, LR 2013	342	\$12	+\$6
<b>3. Late loan delivery:</b> Received storage loan in January	478 farmers	Western Kenya, LR 2013	314	\$6	No change*

\*Measured differences were insignificant at the p=0.1 level

### Adoptability

**Cost:** Farmers receiving the loan were required to pay interest at a rate comparable to the standard interest rate for One Acre Fund loans. While interest does increase the cost of receiving credit, farmers are given 9 months to repay the loan. This long repayment period reduced repayment pressure.

**Complexity:** The maize storage loan closely mirrors the repayment structure of a typical One Acre Fund loan. This product is not more complex than the standard credit offering.

**Preference:** For the LR 2015 season (long rains 2015 season), 23 percent of farmers in Kimilili district (2,248 farmers) requested to receive the loan. One Acre Fund is currently experimenting with strategies to ensure adherence to the loan's stipulation that the farmers store their maize until March. These strategies may affect farmer preference for the loan and increase operational complexity, but are necessary to ensure the expected impact.

### Operability

**Timing:** An important output from this study is that loan timing matters – farmers benefit more from loans that are delivered immediately after the harvest. This timing is operationally beneficial for One Acre Fund as January, the alternative loan delivery period, is busy with pre-payment and logistics preparations.

**Monitoring:** One Acre Fund is trialing several strategies to determine the importance of field officer oversight on farmer compliance with the loan expectation that farmers store their maize until March.

**Training Complexity:** Again, thanks to the similarity between the storage loan and the One Acre Fund core program loan, field staff did not face significant obstacles in training farmers. Focus groups conducted at the time of the study confirmed that participating farmers understood clearly that receiving the loan would allow them to delay selling their grain and access higher market prices later.<sup>iv</sup>

**Sustainability:** The maize storage loan can also contribute to overall organizational sustainability, as it is a low cost, low complexity, and a highly demanded/adopted product

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### Next Steps

In 2015, One Acre Fund will:

- Evaluate storage pledge compliance strategies to help farmers keep to their goal of storing three bags of maize for three months. The trial launched in November 2014 and will run for 6 to 8 months collecting data on sales, purchase and consumption behavior.
- Depending on the results of this follow-up study, One Acre Fund aims to roll this product out to full-scale.

## Actellic Super: Product Overview

### Summary

Actellic Super is widely known and accepted as an effective tool for controlling post-harvest grain losses. The active ingredient kills storage pests through contact and vapor. Actellic Super provides farmers with three months of protection from storage pests.

### Adoption at Scale

Actellic Super is the most widely adopted, non-compulsory product offered by One Acre Fund. For the 2015 long rain season, 106,866 farmers, or 57 percent of all farmers, requested Actellic Super as an additional part of their One Acre Fund package. Perhaps more impressive is that this number is even higher for returning One Acre Fund farmers – 72 percent of returning One Acre Fund farmers purchased Actellic Super for the 2015 season. Returning farmers adopt Actellic Super at a higher rate than new members indicating that the product works well. Farmer trainings emphasize safety and appropriate application timing and rate to achieve the best result.



*Farmer safely applying Actellic Super to her grain. Hailey Tucker/One Acre Fund.*

Cost: Actellic Super adds an additional \$1.50 to farmer loans. One Acre Fund’s experience shows that this cost is not a deterrent to wide-scale adoption.

Complexity: Farmers do not perceive Actellic Super to be a complex product to use. One Acre Fund bundles safety equipment with the product and carefully trains farmers on proper application to make it easy and safe for farmers.

Preference: The strong adoption numbers demonstrate a clear farmer preference for Actellic Super.

### Operability

Sourcing: Actellic Super is easily available at scale from Twiga Chemical for \$2 USD per 200 grams packet.

Distribution: Actellic Super does not present any distribution complexities. Currently, field officers carry the Actellic top-up packets to farmers at their group meetings. This method could become a

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constraint at high client densities. In that case, One Acre Fund could ship the Actellic Super with other top-up items on trucks. There should be no hazardous interactions affect between Actellic Super and other top-up items such as fertilizer and solar lights.

Training Complexity: One Acre Fund has a field tested training for Actellic Super. Feedback from the field teams indicates that farmers are already familiar with the product and quickly learn the techniques.

### Next Steps

- One Acre Fund will continue to offer Actellic Super at scale.
- Long-term impact is important to One Acre Fund, particularly with regards to pesticide use and household health. One Acre Fund will continue to keep up-to-date on expert consensus regarding Actellic Super and other storage pesticides to prevent and mitigate any long-term detrimental effects.

## VI. Conclusions

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### Storage Impact and Profit

- The PICS improved storage bag gives farmers a tool by which they can preserve their grain at a higher quality for longer and helps them access higher market prices. In a study of Rwandan farmers, PICS led to increase bean sales and increased earnings of \$13 USD from those sales.
- Farmers demand and benefit from timely credit in the form of post-harvest storage loans. Post-harvest credit allows farmers to store more grain and sell at higher prices later in the season. Loan client density and the timing of loan delivery matters for household earnings. Farmers in lower loan density villages where less maize was taken off the market were able to benefit more from the seasonal price change than farmers in higher loan client density areas. In addition, farmers who received the loan closer to harvest time were better positioned to manage their maize stores and make a profit.

### Farmer Adoption

- For the Rwanda 2015 B season, 15 percent of farmers have requested PICS as part of their package. One Acre Fund anticipates that adoption will increase as farmers see the benefit their neighbors gain from the product.
- In Kenya, the average PICS adoption rate across two trial districts was 42 percent (3,079 farmers). This adoption rate is promising for adoption at full scale.
- Twenty-three percent of One Acre Fund farmers in Kenya elected to receive the maize storage loan. This high adoption rate indicates the popularity of the product and how much farmers value it.
- Actellic Super is one of the most popular top-up products One Acre Fund offers. For the 2015 long rains, 106,865 farmers requested Actellic Super as part of their package.

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### Operability at Scale

- PICS and Actellic Super are both highly operable at scale. At higher client densities, One Acre Fund would need to modify the distribution models for each of these products but this is not an obstacle to reaching full scale.
- One Acre Fund is testing several loan compliance strategies to increase compliance with the loan stipulations. The results of this study will inform how One Acre Fund moves to scale with this product, specifically the degree to which farmers will need to be monitored by field staff.

### Next Steps

In 2015, One Acre Fund will:

- Offer PICS bags at scale in Kenya and progress PICS bags toward a full scale offering for the 2016B season in Rwanda.
- Continue offering Actellic Super storage pesticide at scale.
- Evaluate loan compliance enforcement strategies and use the study findings to modify and progress the maize storage loan product to scale.
- Experiment with other storage products such as drying tarps that allow farmers to more easily dry their grain to the correct moisture level.
- Continue to assess how all of these products can work in concert to minimize post-harvest storage loss and maximize benefits to farmers.

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<sup>i</sup> [http://siteresources.worldbank.org/INTARD/Resources/MissingFoods10\\_web.pdf](http://siteresources.worldbank.org/INTARD/Resources/MissingFoods10_web.pdf)

<sup>ii</sup> This equals 2082.5 Rwandan Francs. One Acre Fund also sells the bags off credit for 1750 (\$2.53)

<sup>iii</sup> Farmers were limited to one bag per client. We limited adoption because we didn't have firm numbers on impact at the start of enrollment and distribution.

<sup>iv</sup> Selling Low and Buying High: An Arbitrage Puzzle in Kenyan Villages, Marshall Burke, March 20, 2014, unpublished.