Contracting and quality upgrading: Evidence from an experiment in Senegal

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Abstract

Linking producers to export markets can improve incomes and welfare, but accessing these markets requires meeting international quality standards. Contracts between producers and buyers may facilitate meeting these standards by aligning incentives, alleviating constraints, and reducing uncertainty for producers. In partnership with two groundnut farming cooperatives in Senegal, we implement a new contracting arrangement that bundles price premium certainty with training and credit for the purchase of a new quality-improving technology. We conduct a randomized experiment to test whether this contract induces adoption of the technology and improvements in production quality. Producers randomly offered the contract are significantly more likely to purchase and use the technology. In areas where quality is otherwise low due to agro-climatic conditions, producers in the treatment group produce significantly higher-quality groundnuts. We also find that producers in the treatment group increase output sales to the cooperative on average. Importantly, the new contract is significantly more effective at increasing sales to the cooperative for producers who are more reciprocal and for whom signaling reliability is more valuable.

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1 Introduction

Linking producers to global value chains can increase incomes, improve productivity, and improve welfare (Minten et al., 2009; Reardon et al., 2009; Atkin et al., 2017; Barrett et al., 2020; World Bank, 2020). To participate in these value chains, however, producers must be able to meet international quality standards, which can present a major barrier to market access (Ferro et al., 2015; Fontagné et al., 2015; Fernandes et al., 2019). In this paper, we propose an intervention that aims to increase producers' ability to meet quality standards and enter global value chains.

Improving production quality often requires producers to change practices or invest in new technologies. Existing evidence suggests improving market conditions and resolving producer uncertainty can increase technology adoption and production quality (Saenger et al., 2014; Atkin et al., 2017; Bernard et al., 2017; Abate et al., 2018; Macchiavello and Miquel-Florensa, 2019). Contracts may enable these changes by aligning incentives for producers and buyers, facilitating access to credit and information, and ultimately providing reliable market access (Minten et al., 2009; Bellemare and Bloem, 2018; Arouna et al., 2019; Bellemare et al., 2020; Casaburi and Reed, 2020). However, sustaining contracting arrangements can be difficult in contexts with limited institutional capacity or robust spot markets (Fafchamps, 2004; Bellemare, 2010; Mujawamariya et al., 2013). It remains an empirical question under what conditions contracts can succeed, particularly when a buyer offers a new contract which requires producers to change practices or meet previously-unknown quality standards.

We present experimental evidence that a new contract farming arrangement can increase compliance with food safety quality standards by inducing adoption of a new quality-improving technology. The context of our study is groundnut cultivation in Senegal, a country where groundnuts are both the most valuable export crop and widely consumed locally.[1] We focus on one specific food safety quality standard—aflatoxin contamination—which affects both export market access and public health. Aflatoxins are a Group 1 human carcinogen (IARC, 1993, 2012; National Toxicology Program, 2016) produced by a fungus (*aspergillus flavus*) which contaminates staple crops including groundnuts, maize and rice.[2] Many countries impose aflatoxin standards for imported commodities, with the European Union's rules among the strictest in the world (Garcia-Alvarez-Coque et al., 2020). Despite the health and economic consequences of aflatoxin contamination, at baseline we find low

[1] Groundnuts are grown by more than half of households in extreme poverty, use more than 40% of cultivated land, and are widely consumed in a variety of forms in Senegal (World Bank, 2015). In 2018, Senegal was the 7th largest producer of groundnuts in the world (USDA Foreign Agricultural Service, 2020).

[2] One report called aflatoxins "amongst the most potent mutagenic and carcinogenic substances known" (EFSA, 2007). The carcinogenic risks of aflatoxin exposure are compounded by high rates of Hepatitis B in many low-income countries (Turner et al., 2003).Chronic exposure can also contribute to childhood malnutrition and immunosuppression (Gnonlonfin et al., 2013). Aflatoxin contamination is an increasingly salient concern for producers of a variety of staple crops. With climate change exacerbating changes in rainfall patterns (Clavel et al., 2013), aflatoxins may be responsible for up to one quarter of all liver cancer cases worldwide and more than four billion people may be chronically exposed (Williams et al., 2004; Liu and Wu, 2010; Liu et al., 2012).

awareness of the problem among groundnut farmers.

In partnership with two farming cooperatives in the "groundnut basin" of Senegal, we market the bio-control product Aflasafe, a new quality-improving technology, to farmers in 40 villages. This new technology allows farmers to treat their fields and prevent aflatoxin-causing *a. flavus* fungi from developing on crops. Aflasafe was not previously available in Senegal,[3] and agronomic evidence suggests it can reduce aflatoxin contamination significantly (Bandyopadhyay et al., 2019; Senghor et al., 2020). The technology is relatively low-cost[4] compared to other mitigation strategies, and has the added advantage of providing lasting protection to crops during storage and transport.

To test the role of contracting in facilitating quality improvements, we design a new contract that cooperatives offer to randomly-selected members. This new contract provides farmers with credit to purchase the quality-improving technology Aflasafe, training on how to use the technology, and a guaranteed price premium conditional on quality certification. The contract builds on the existing informal contracting arrangement between cooperatives and members, in which cooperatives provide farmers seeds and fertilizer on credit and deduct the costs from farmers' revenues after harvest. We implement a cluster-randomized experiment to test this new contract with a sample of 396 farmers in 40 villages. We measure the impact of the randomly-assigned new contract offer on Aflasafe adoption, aflatoxin standard compliance, and output sales to the cooperative.

Producers randomly offered the contract are significantly more likely to adopt Aflasafe. Take-up of the technology in control villages was relatively low at 10 percent.[5] By comparison, in villages where farmers received the new contract offer, take-up was 89 percent. This implies an estimated average treatment effect of 79 percentage points, significantly larger than most previous studies on technology adoption.

We find that the contract offer resulted in measurably higher-quality production. Our data collection confirms that aflatoxin contamination is indeed a problem in the groundnut basin of Senegal: more than 30 percent of farmers in the control group exhibited contamination exceeding European Union import standards. We find that farmers that received the new contract offer were 12% more likely to comply with these strict standards, but the effect is imprecisely estimated.[6] However, in line with previous work (Waliyar et al., 2015; Magnan et al., 2019), we find that aflatoxin contamination is highly variable across space, even in the absence of any mitigation measures. Temperature and rainfall can significantly affect aflatoxin contamination risk (Cotty and Jaime-Garcia, 2007; Bowen and Hagan, 2015). Using

[3]After more than five years of efficacy trials in Senegal and more than ten years of development in Nigeria, led by the International Institute for Tropical Agriculture, Aflasafe SN-01 received regulatory approval and launched for commercial sale in 2019. Senegal is one of the first countries in Africa where Aflasafe is produced locally by a commercial partner.

[4]Treating one hectare of cropland costs about $17 USD at market price.

[5]This is not out of line with results from other studies of Aflasafe in particular (Hoffmann et al., 2018b) or smallholder technology adoption more generally.

[6]Previous work in Senegal confirmed that Aflatoxin levels at harvest are correlated with aflatoxin-albumin adduct (AF-alb), a biomarker of aflatoxin exposure (Watson et al., 2015).

satellite data on growing season temperature and precipitation, we estimate contamination risk using samples collected from control farmers. We then predict which villages experienced the highest average risk of contamination given growing-season temperature and rainfall. In areas where contamination risk was highest, the contract offer has a large and positive effect on standard compliance. In our preferred specification, farmers in high-risk areas who receive a contract offer produce groundnuts 49% more likely to comply with the strictest international standards.

The contract offer also significantly increases output sales to the cooperative. This outcome is highly policy-relevant: existing work on cooperatives in this and similar settings has thoroughly documented the challenges they face in aggregating output (Bernard et al., 2008, 2015; Aflagah et al., 2019). Our setting is no exception.[7] Only 23 percent of farmers in control villages sold any output to the cooperative at endline. In our preferred specification, the treatment increased the probability of output allocation to the cooperative by 52%. We observe similar effects at the intensive margin of quantity sold to the coop, with treated farmers increasing total output sales to the cooperative by about 65%.

Behavioral characteristics like reciprocity can play important roles in commercial relationships, particularly in the context of repeated interaction (Sobel, 2005; Leider et al., 2009; Finan and Schechter, 2012; Ligon and Schechter, 2012). Given the contracting environment we study, with low capacity for external enforcement, understanding how contract success varies with farmer characteristics is instructive about the mechanisms driving the average effect we uncover. We uncover substantial heterogeneity in the treatment effect on output sales to the cooperative, with significant variation by farmer reciprocity. We measure intrinsic reciprocity using questions from the Global Preferences Survey (Falk et al., 2016, 2018). Among control farmers, high measured levels of intrinsic reciprocity are associated with lower likelihood of selling output to the cooperative. By comparison, highly reciprocal treated farmers are significantly more likely to sell any output to the cooperative. Together, these two facts result in a treatment effect on high-reciprocity farmers of 33 percentage points, nearly three times as large as the average treatment effect we observe.

Reputation and relationship value are another important factor in commercial relationships (Banerjee and Duflo, 2000; Macchiavello and Morjaria, 2015; Ghani and Reed, 2020). In our setting, farmers face few outside options for accessing credit for input purchases, so defaulting on a contract and endangering future credit access may be costly. However, the risk and cost of losing credit access may vary depending on the nature of a farmer's relationship to the cooperative. We test for heterogeneity in output sales to the cooperative by two dimensions that capture elements of relationship value: membership tenure and leadership status. Farmers who are newer cooperative members may be at greater risk of losing future access, if they have not yet established a reputation with the cooperative. Farmers who help

[7] The year of our study was one in which prices in local markets were high; cooperatives, by comparison, are typically constrained to respect official prices set by the government each year. This resulted in even lower-than-normal output sales to the cooperative.

the cooperative as "lead farmers" often receive early access to new technologies for testing and demonstration, and the relationship to the cooperative may be particularly valuable. We observe significant heterogeneity across both dimensions. We find that the treatment effect on output sales to the cooperative is roughly twice as large for new members and lead farmers as the average effect we observe. These results may inform how cooperatives might target contract offers, or suggest a need for complementary interventions to increase contract compliance among other types of farmers.

Our work contributes to the literature in three ways. First, we contribute to a growing literature on contracting in settings with limited enforcement. Existing work suggests contract farming can be an effective avenue for farmers to improve productivity or quality (Arouna et al., 2019; Macchiavello and Miquel-Florensa, 2019).[8] Successful contracting typically depends on either effective institutions or informal relationships, often termed relational contracting (Brown et al., 2004; Michler and Wu, 2020). In keeping with recent work (Antràs and Foley, 2015; Macchiavello and Morjaria, 2015), we find evidence consistent with the idea that longer commercial relationships are more flexible in the presence of a significant shock. Previous work has additionally demonstrated the complementary nature of norms, incentives, and reciprocity in enforcing informal contracts (Charness and Haruvy, 2002; Fehr et al., 2009; Rigdon, 2009; Finan and Schechter, 2012; Kessler and Leider, 2012; Fahn, 2020). We contribute new field-experimental evidence that reciprocity is a determinant of relational contract success.

Second, we contribute to the substantial literature on agricultural technology adoption. Credit, information, and price uncertainty may all be relevant constraints limiting adoption of improve technologies in a particular context (Feder et al., 1985; Foster and Rosenzweig, 2010; Magruder, 2018). Credit in particular, by shifting the timing of payment or salience of the total cost, can increase adoption of a variety of technologies including fertilizer, bednets, and crop insurance (Duflo et al., 2011; Devoto et al., 2012; Tarozzi et al., 2014; Casaburi and Willis, 2018). A growing body of evidence suggests bundling interventions together to address several of these constraints can be highly effective at increasing technology adoption and farmer productivity (Abate et al., 2018; Deutschmann et al., 2019). In our setting, we study the introduction of a brand new technology into the market. We show that bundling credit, information, and price certainty in a contracting arrangement can be an effective tool for buyers to induce widespread adoption of the new technology and ultimately source larger quantities of higher-quality production.

Third, we contribute to a small but important literature on the determinants of aflatoxin mitigation by smallholder farmers. Given the public health implications of widespread aflatoxin exposure, especially in low-income countries, it is of direct policy interest to understand the best strategies for reducing contamination. Previous work on bio-control

[8] Contract farming can also affect other dimensions of farmer welfare, by increasing food security (Bellemare and Novak, 2017) or reducing income volatility (Bellemare et al., 2020).

technology in particular has found that a price premium alone, or a price premium bundled with index insurance, may induce at most modest increases in technology adoption (Hoffmann et al., 2018b; Narayan et al., 2019). More generally, information and price premiums can induce increased adoption of complementary aflatoxin mitigation strategies, like drying crops on a tarp or storing them in hermetic storage bags (Magnan et al., 2019; Bauchet et al., 2020). By contrast, we find that bundling information and a price premium with credit is sufficient to induce high adoption of bio-control technology.

The remainder of the paper is organized as follows. Section 2 provides additional context about aflatoxin and groundnut cultivation in Senegal. Section 3 presents the design of the experiment, and Section 4 provides an overview of the key covariates and outcomes of interest. Section 5 presents the empirical strategy, Section 6 presents the results, and Section 7 concludes.

2 Context

2.1 Groundnuts in Senegal

Groundnut cultivation has represented a significant fraction of economic activity in Senegal since well before independence.[9] However, as quality standards and the nature of the global groundnut market shifted from oil and processed material to whole nuts, Senegal's share of the international groundnut trade fell from 17 percent in the early 1960s to a low of less than 1 percent in the 1990s. More recently, after easing export restrictions on whole nuts, Senegal has approached 10 percent of world trade in nuts, but with high levels of inter-annual volatility. (World Bank, 2017).[10] Groundnut productivity largely stagnated after the 1960s and Senegal's share of world groundnut production has remained roughly stable at 2-3 percent since the 1990s (Kelly et al., 1996; World Bank, 2017).

The center of groundnut production is the city of Kaolack and the surrounding region, aptly termed the "groundnut basin." Shifting rainfall patterns in the groundnut basin since the 1980s have increased the risk of *a. flavus* development and aflatoxin contamination (Clavel et al., 2013). Consequently, dietary aflatoxin exposure in the groundnut basin is particularly high (Watson et al., 2015). Despite significant work to identify seed varieties more resistant to aflatoxin, agronomists have thus far failed to identify any variety which was completely resistant to aflatoxin contamination (Waliyar et al., 1994; Anderson et al., 1995; Holbrook et al., 2000; Clavel et al., 2013), although new work shows promise in developing aflatoxin-resistant seeds (Sharma et al., 2018).

[9] Cultivation of groundnuts began in Senegal in the 1840s and grew quickly into a major export during the era of French colonial rule (Brooks, 1975).

[10] Despite changes in the nature of the global market, the domestic market is still largely structured to protect groundnut oil producers (including a large state-owned company), with high implicit taxation eroding incentives for non-oilseed production (Masters, 2007; World Bank, 2017). However, in a sign of shifting priorities for rural producers and firms, repeated efforts to impose an export tax on whole nuts have largely failed under public pressure (Fofana et al., 2018).

Groundnut farmers in Senegal are typically members of a cooperative or rural-producers organization. Groundnut cooperatives in Senegal have roots in post-colonial political economy; the first president invested heavily in rural welfare through a robust state-controlled system of cooperatives (Casswell, 1984). In subsequent decades, state involvement in the cooperatives declined. Productivity also lagged as development of new seed varieties slowed and the parastatal groundnut oil producer faced a series of financial difficulties. In recent decades, many cooperative organizations have provided at best limited benefits to members (Bernard et al., 2008). However, work by the Senegalese government and international organizations has resulted in a new class of cooperative organizations more active in input provision and output commercialization (Clavel and Gaye, 2018; Eclosio, 2018). These cooperatives distribute seeds, fertilizer, and pesticides to farmers, typically on credit repayable in kind after harvest. Farmers express their input needs in the months before planting, and the cooperatives aggregate farmer requests to purchase inputs in bulk and re-sell them to farmers. These cooperatives also provide extension services to farmers, with trained technicians on staff and lead farmers active in many villages. They aim to commercialize output collectively, but in practice often pay only the government-set price floor and resell output to the quality-insensitive state-owned groundnut company.[11]

In this setting, farmer non-compliance with relational contracts (i.e., side-selling to buyers other than the cooperative) is common, but inconsistent, as spot market prices are driven almost entirely by Chinese demand with significant inter-annual variation. Cooperatives may punish complete non-compliance by restricting future credit access. However, the main channel by which cooperatives encourage compliance is positive in nature: namely, access to trials and new technologies. Many of the "new class" cooperatives in Senegal are active in developing and testing new seed varieties, new farming techniques, and new contracting arrangements (Clavel and Gaye, 2018; Eclosio, 2018). Conversations with cooperative leaders suggest they prefer to allocate access to these trials to farmers they see as reliable or highly skilled.

2.2 Aflatoxins

The quality measure we study in this paper is aflatoxin contamination. Aflatoxins are toxic compounds produced by *aspergillus flavus*, a fungus which contaminates crops from soil and spreads during storage (Frisvad et al., 2019). Aflatoxins affect a variety of staple and cash crops including maize, rice, and groundnuts (Udomkun et al., 2017). Across sub-Saharan Africa, research has found consistently high levels of human and animal aflatoxin exposure (Watson et al., 2015; Sirma et al., 2018; Blankson et al., 2019). Aflatoxin exposure has a variety of health impacts. Acute exposure to high levels of aflatoxins can be deadly (Probst

[11] The price floors that cooperatives and oil-press companies in Senegal follow are set annually by the National Inter-professional Groundnut Committee (CNIA), with some debate over how much the state influences the price chosen each year (Diagana, 2008).

et al., 2010; Kamala et al., 2018). Chronic exposure to lower levels of aflatoxins can cause child stunting, cancer, and immunosuppression (Coursaget et al., 1993; Wild, 2002; Hoffmann et al., 2018a; Voth-Gaeddert et al., 2018; Watson et al., 2018).[12] Aflatoxin exposure also affects livestock health and can transmit to humans via milk products (Bryden, 2012).

Governments and large buyers of crops across Africa have identified aflatoxin control as a key public health challenge (Partnership for Aflatoxin Control in Africa, 2015). The European Union began implementing harmonized aflatoxin standards in 2002 (Otsuki et al., 2001), with significant effects on Senegalese firms seeking to export whole groundnuts to European markets (Mbaye, 2005). This is not a problem unique to Senegal: existing work suggests firms and agricultural exporters are often constrained by stricter product standards in destination markets (Ferro et al., 2015; Fontagné et al., 2015; Fernandes et al., 2019).[13] African producers and exporters were particularly impacted by changes in EU standards (Agyekum and Jolly, 2017).

Aflatoxins are difficult to control because they are not directly observable: contaminated crops can look, smell, and taste identical to non-contaminated crops. Chemical tests for aflatoxins exist, but are not widely available, and the costs of consumable materials and testing equipment are non-trivial.[14] Early conversations with exporters and agro-processors during the design phase of this project suggest many are concerned about aflatoxins and eager to source low-aflatoxin groundnuts, but lacked the means to easily identify them.

Fragmented value chains between smallholder farmers and consumers, agro-processors and exporters make aflatoxin control along the chain a challenging and potentially costly proposition. Existing research on reducing aflatoxin incidence at the farmer level has found that low-cost practices (such as drying crops on a tarp) can reduce aflatoxin contamination (Turner et al., 2005; Magnan et al., 2019; Pretari et al., 2019; Bauchet et al., 2020; Jordan et al., 2020). However, the market rewards for a small farmer to reduce aflatoxin contamination are unclear. Consumer demand for reduced aflatoxin in local markets is inconsistent (Prieto et al., 2019; Hoffmann et al., 2020b,a). Contaminated crops are often sold to consumers in powdered or transformed form (Florkowski, 2014). Exporters and other quality-sensitive buyers typically do not work with small farmers directly.

2.3 Bio-control for aflatoxin reduction

Agronomists have developed new bio-control technology to fight against aflatoxin contamination.[15] Marketed under the umbrella brand name *Aflasafe*, this technology is designed to

[12] One study hypothesizes that reducing aflatoxin exposure to non-detectable levels could reduce liver cancer cases in high-risk areas by 23% (Liu et al., 2012).

[13] In addition, previous work in Senegal found that tightening standards for fruit and vegetable exports to the EU induced structural changes in the supply chain (Maertens and Swinnen, 2009).

[14] In 2016, ICRISAT announced a new low-cost aflatoxin test kit that would be available for less than $2 per test (compared to $20-25 per test for existing kits). However, this technology is not yet widely available.

[15] While this technology is new for African contexts, similar aflatoxin bio-control products have been used commercially in the United States for more than 20 years in a variety of crops (Dorner and Lamb, 2006;

limit the development of toxic strains of *aspergillus flavus* in fields (Bandyopadhyay et al., 2019). In each country where Aflasafe has launched,[16] local strains of *a. flavus* are first collected to identify competitive strains which do not produce aflatoxins. These strains are isolated and replicated to produce products like Aflasafe SN-01, which launched in Senegal and the Gambia in 2019 after more than five years of efficacy trials (Senghor et al., 2020). The technology uses sterilized seeds (which will not grow) as a delivery mechanism, with the concentrated Aflasafe treatment applied as a seed coating. To protect a plot, farmers broadcast the Aflasafe-coated sterile seeds in the field 4-6 weeks after planting. The atoxigenic Aflasafe strains spread in the fields and prevent the aflatoxin-causing strains from developing on crops.

Compared to existing aflatoxin control strategies, Aflasafe has two key advantages. First, it provides lasting aflatoxin protection even if storage conditions along the value chain are not always ideal. Agronomic research suggests that, even if non-treated and treated samples show similar aflatoxin levels immediately post-harvest, poor storage conditions will cause measurable differences in contamination in a matter of weeks (Senghor et al., 2020). Second, Aflasafe may be more cost effective than hermetic storage bags, another proposed solution for aflatoxin control. Treating one hectare of groundnuts with Aflasafe costs about $17 USD at current market prices. By comparison, purchasing hermetic bags in Senegal to store the production from one hectare may cost $40 or more (Bauchet et al., 2020).

3 Research Design

We implemented this project in partnership with two cooperatives located in the groundnut basin of Senegal, in the Kaolack and Fatick regions (Figure 1). These cooperatives are active in providing services to members, including input distribution, access to credit, and agricultural extension support. They focus primarily or exclusively on groundnut production. In what follows, we refer to our partner cooperatives as Northern and Southern, indicating their location relative to the Saloum river. Each cooperative is organized into village sections, where each section typically has a president and one or more lead farmers.[17] Each cooperative has a membership of at least 1500 farmers divided into more than 50 village-level sections. Using the membership lists of each cooperative as a sampling frame, we selected a study sample of farmers from 40 villages. We initially sampled 10 farmers per village, with 5 replacement farmers available, and ended up with a final sample of 396 participating farmers after the baseline.

We assigned 20 villages each to treatment and control groups.[18] Village randomization

Dorner, 2009; Doster et al., 2014).

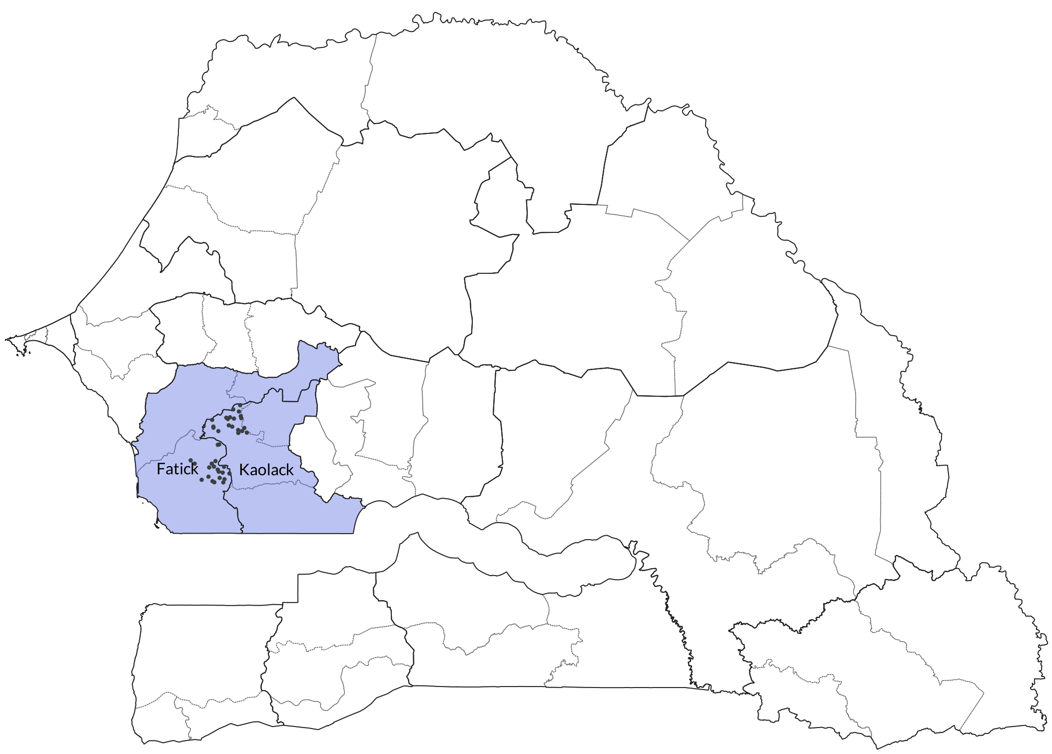
[16] As of September 2020, localized versions of Aflasafe are on sale in seven countries in Africa, with development at various stages in thirteen more.

[17] Lead farmers and village presidents are typically the channels by which the cooperatives diffuse information about practices and new technologies.

[18] Because *aspergillus flavus* can spread between neighboring fields, we chose to randomize treatment at the

was stratified at the rural commune level, the smallest level of administrative division at the rural level. All farmers were offered a free aflatoxin test, and all farmers received the same information about Aflasafe. Farmers in the treatment villages were eligible to purchase Aflasafe on credit, repayable in cash or in kind after harvest. They were also promised a minimum price premium, relative to the state-set price typically offered by cooperatives, of 40 CFA (about $0.07) per kg conditional on the results of an aflatoxin test. Farmers in control villages were eligible to purchase Aflasafe, but had to pay up front. They were also informed that they could have their production tested for aflatoxins, but with no promise of a price premium. Farmers in the treated group additionally received a promise of assistance applying the product from trained cooperative extension agents. After farmers made adoption decisions, both groups received a similar level of help applying the product.

Figure 1: Study regions and sampled villages



We conducted a baseline survey in June and July 2019, collecting detailed information about farming practices in the previous season and plans for the current season, as well as aflatoxin awareness, involvement with and trust in the cooperative, and reciprocity. We introduced Aflasafe to farmers at the end of the baseline survey. First, enumerators read a

village level rather than the individual level.

script explaining the health risks caused by aflatoxin exposure. Then, they explained how Aflasafe works, discussed with farmers how to use it, and showed farmers a video which demonstrated how to apply Aflasafe to a field.[19] Finally, they distributed to each farmer a ticket they could redeem with the cooperative to access 10kg of Aflasafe, sufficient to treat one hectare of groundnuts. Farmers learned the details of their treatment assignment upon receiving this ticket, which included a unique code for each farmer as well as a reminder about the contract terms for treated farmers.

Next, in August 2019 we called all participants to inform them that Aflasafe had become available at their cooperative[20] and remind them of the terms of their treatment assignment. We additionally asked for the date they planted their groundnuts, and informed them of the suggested window for Aflasafe application based on their planting date (roughly six weeks after planting).

Aflasafe distribution was managed directly by the cooperatives, and was run similarly to how other inputs are distributed. This means that farmers in villages near to the cooperatives go directly to the warehouse to pick up inputs, whereas for villages further from the warehouse, the cooperative collects orders in advance and organizes a delivery by truck. Enumerators were present in the headquarters of each cooperative during distribution to ensure treatment status was respected (i.e., that control-group farmers who had to purchase the product up front did pay up front, and treatment-group farmers who could receive product on credit received the product on credit).

After the product was distributed, extension agents from each cooperative visited each village to help farmers apply the product correctly. Although the application process is simple—farmers broadcast 10kg of the product relatively uniformly over one hectare—agronomic field trials suggest that effectiveness may be sensitive to correct application. These trained agents helped ensure correct application and recorded the date on which farmers applied the product. All adopting farmers received the same extension support from the cooperative.

After harvest, in December 2019 and January 2020, we sampled and tested the groundnuts to determine aflatoxin levels for farmers in the sample. Some farmers delivered groundnuts for sale to the cooperative, and for these farmers we collected a sample from the groundnuts delivered for sale. However, market conditions meant buyers outside the cooperative were often paying farmers higher prices, so many farmers elected to sell their groundnuts elsewhere and simply reimburse the cooperative in cash to cover their credit.For these farmers, we worked with village section presidents and agents from the cooperative to collect samples. Despite offering farmers a significant premium for a sample sufficient to measure aflatoxin

[19]The full script (translated to English) is shown in Appendix D. The video can be seen here: video link (Wolof).

[20]When we initially surveyed farmers during the baseline survey, we expected Aflasafe to be available for them no later than the end of July. Due to delays in production by the local manufacturer, the product was not actually available until late August.

levels, we were ultimately only able to test 83% of farmers. Some attrition at this stage was due to crop failure, whereas others reported selling their entire crop before we tried to collect a sample. To test the level of aflatoxin, we conducted lateral flow tests using a Neogen Raptor reader and standard sampling and testing procedures used by IITA for all Aflasafe development activities.

Farmers from treated and control villages who chose to adopt Aflasafe and achieved aflatoxin levels less than 4 parts per billion (ppb) received a premium price from the cooperative for their certified groundnuts. This premium was paid only for bags delivered to the cooperative in advance of testing, and the resulting bags were sampled and certified following the test. Farmers were paid 250-275 CFA ($0.43-0.47) per kg for their certified production - the final price was set by each cooperative depending on their logistical overhead costs. This represented a significant premium over the government-set price of 210 CFA ($0.36) per kg, although anecdotal reports suggest high export demand from Chinese buyers resulted in comparable prices in local markets without quality certification.

Finally, we surveyed farmers in June 2020 to learn about groundnut production and revenue. This endline survey was conducted by phone due to the COVID-19 crisis.

4 Data

In this section we describe the characteristics of the study population and the market environment. We additionally present information and summary statistics about the outcomes of interest.

4.1 Baseline

Table 1 presents summary statistics and baseline balance tests. The characteristics of our sample motivate the importance of our project. In particular, note that the median farmer does not have a savings account (either in a bank or with a mobile money provider), consumes some of his output, and was unaware of aflatoxin. Most farmers have experience adopting fertilizer and pesticides, but yields-per-acre are relatively low by global standards at about 900 kgs/hectare.[21]

We elicited several measures of potential behavioral mechanisms, following our Pre-Analysis Plan, using questions drawn from Falk et al. (2016, 2018). In particular, we elicited measures of intrinsic reciprocity, patience, and risk aversion. Intrinsic reciprocity plays an important role in repeated interactions, and individuals may reward past kindness or punish past unkindness (Sobel, 2005; Cabral et al., 2014). We hypothesized that highly reciprocal individuals may be more affected by a contract offer; namely, high-reciprocity

[21] Groundnut yields in China (the largest producer in the world) recently exceeded 3.5 metric tons per hectare. By comparison, yields in India (the second largest producer) are more comparable at 1-1.3 metric tons per hectare (USDA Foreign Agricultural Service, 2020).

Table 1: Baseline balance and summary statistics

Variable	(1) Control Mean (SD)	(2) Treatment Mean (SD)	Difference (2)-(1) [p-value]
Demographic variables			
Married (0/1)	0.92 (0.27)	0.91 (0.29)	-0.01 [0.61]
Polygamous marriage (0/1)	0.38 (0.49)	0.46 (0.50)	0.09 [0.12]
Female (0/1)	0.36 (0.48)	0.31 (0.46)	-0.04 [0.52]
Household head (0/1)	0.63 (0.48)	0.62 (0.49)	-0.01 [0.82]
Completed secondary school [resp.] (0/1)	0.11 (0.31)	0.10 (0.30)	0.00 [0.91]
Completed sec. school [any in HH] (0/1)	0.57 (0.50)	0.60 (0.49)	0.02 [0.79]
Household size	16.17 (10.11)	16.39 (9.33)	0.13 [0.89]
Children in household	6.63 (4.77)	6.99 (5.11)	0.31 [0.56]
Age	49.11 (13.01)	47.66 (12.82)	-1.49 [0.29]
Agricultural variables			
Aware of aflatoxin (0/1)	0.09 (0.29)	0.13 (0.34)	0.04 [0.24]
Savings account (0/1)	0.34 (0.47)	0.31 (0.46)	-0.03 [0.57]
Lead farmer (0/1)	0.11 (0.31)	0.15 (0.35)	0.03 [0.44]
Used fertilizer (0/1)	0.66 (0.47)	0.75 (0.43)	0.08 [0.15]
Used pesticides (0/1)	0.62 (0.49)	0.58 (0.50)	-0.04 [0.51]
Consumes some output (0/1)	0.72 (0.45)	0.74 (0.44)	-0.01 [0.89]
Sold to cooperative (0/1)	0.29 (0.46)	0.40 (0.49)	0.10 [0.12]
Sold to other traders (0/1)	0.77 (0.42)	0.75 (0.43)	-0.01 [0.86]
Kept as seeds or given away (0/1)	0.71 (0.46)	0.71 (0.46)	0.01 [0.78]
Groundnut hectares cultivated	3.56 (2.64)	3.40 (2.52)	-0.09 [0.74]
Groundnut yield (kgs/hectare)	859.31 (678.48)	909.49 (922.68)	36.55 [0.57]
Recent cooperative member	0.30 (0.46)	0.24 (0.43)	-0.06 [0.54]
Behavioral variables			
Risk loving (0/1)	0.21 (0.41)	0.24 (0.43)	0.03 [0.34]
Patient (0/1)	0.79 (0.41)	0.78 (0.41)	-0.01 [0.78]
Reciprocal (0/1)	0.45 (0.21)	0.49 (0.25)	0.04* [0.06]
p-value, F-test of joint orthogonality across groups (asymptotic)			0.00
p-value, F-test of joint orthogonality across groups (empirical CDF)			0.31
Number of observations			396

Note: standard errors for differences for each baseline variable are clustered at the treatment assignment (village) level. Individual balance tests include commune fixed effects to account for randomization stratified at commune level. The p-value for the asymtotic test that observations are jointly orthogonal across groups is estimated using OLS, with treatment assignment as the dependent variable, all baseline covariates as independent variables, commune fixed effects, and standard errors clustered at the treatment assignment level. The p-value for the empirical CDF test is estimated using 1000 placebo draws that re-assign treatment at the village level, within commune strata, and computing the share of placebo F-statistics larger than the actual test statistic (Hansen and Bowers, 2008).

treated farmers may be more likely to adopt the technology and sell output to the cooperative. We additionally hypothesized that patience and risk aversion would moderate adoption decisions: for control farmers, adoption required payment now for a possible benefit in the future, whereas treated farmers could delay payment until harvest and had more certainty about the potential benefits.

Table 1 additionally presents balance tests. We test for balance individually and jointly across treatment and control groups. We find only one variable (reciprocity) with a statistically significant difference at the 10% level. To test joint balance, we first implement the conventional asymptotic test, regressing the treatment dummy on all the variables presented in Table 1, with standard errors clustered at the village level. Despite failing to find a significant difference in any individual variable, this test does reject that treatment is jointly orthogonal to all baseline variables. However, as Hansen and Bowers (2008) point out, when the number of covariates is "large" relative to the number of clusters, asymptotic tests may over-reject the null. Therefore we additionally conduct a randomization inference procedure (Heß, 2017), taking placebo draws of treatment status at the village level (stratified by commune), and repeating the regression of placebo treatment status on the set of baseline covariates to generate an empirical CDF of F-statistics. We fail to reject the null of joint orthogonality using this approach. There is some disagreement in the literature about how to account for balance, or imbalance, in a randomized trial (Imai et al., 2008; Bruhn and McKenzie, 2009; Mutz et al., 2019; Snyder and Zhuo, 2020). In our preferred specifications below, we control only for commune, the level at which cluster randomization was stratified. However, we also present results which control for all baseline covariates shown in Table 1, which rarely leads to any change in the statistical significance of our results.

4.2 Adoption and Intentions

Next, we turn to our primary outcome measure: adoption of the new technology. We observe two potential measures of adoption, based on administrative data and self-reported endline data. The administrative measure relies on two datasets shared by our partner cooperatives: the administrative logs from distribution, and field visit logs by extension agents. These two datasets coincide for 94% of observations.[22] In the analysis that follows, we use a harmonized measure which flags a farmer as having adopted if either the distribution logs or field visit logs indicate adoption. However, results are robust to using each underlying log file individually.[23] The second measure relies instead on the self-reported use of Aflasafe from the endline survey. As Figure 2 demonstrates, self-reported Aflasafe use is slightly higher for control farmers and slightly lower for treated farmers compared to the administrative measure. The difference in these two measures could indicate some leakage from treated farmers to control farmers, even though treatment was randomized at village level and

[22]For the other 6%, about 2% are flagged as purchasing Aflasafe without applying it, and about 4% are flagged as receiving extension assistance applying Aflasafe without purchasing it.

[23]We additionally sent enumerators to audit a randomly-selected 50% of villages and confirm the technology was distributed and applied. In each village, they spoke to up to two randomly-selected adopters and non-adopters (as defined by the field visit logs). In only one case did they find respondent flagged as a non-adopter in field visit logs but who reported receiving and applying the technology. In one case they also found a respondent flagged as an adopter who elected not to apply the technology.

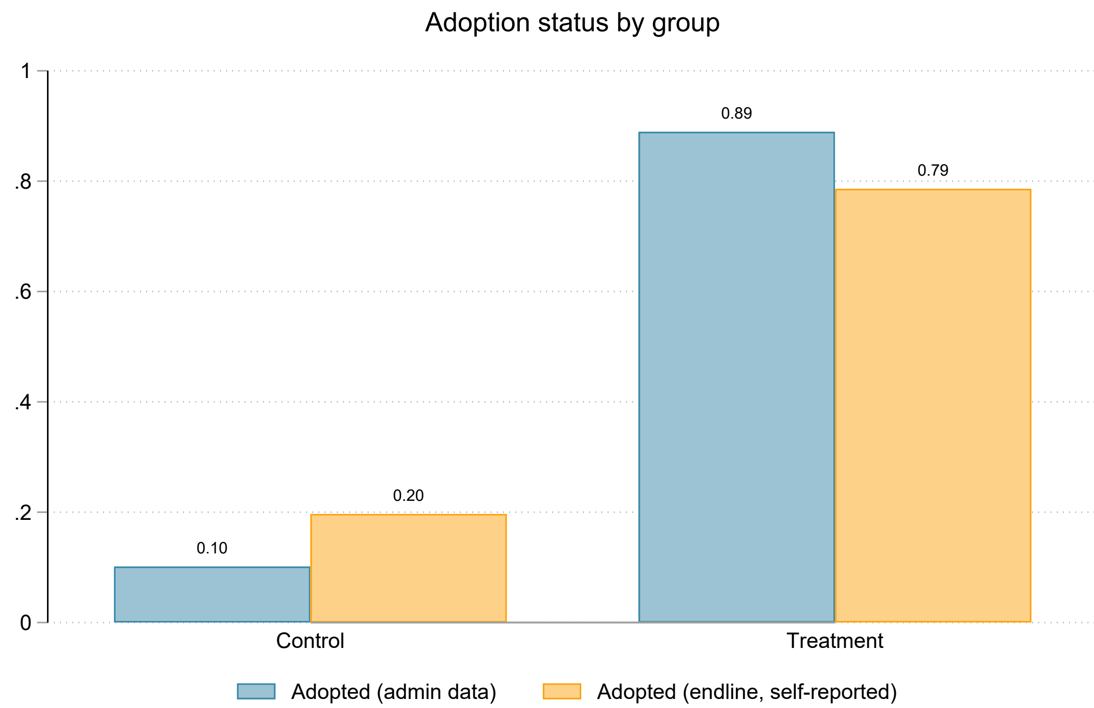


Figure 2: Aflasafe adoption

adopting farmers received assistance and supervision applying the product.[24]

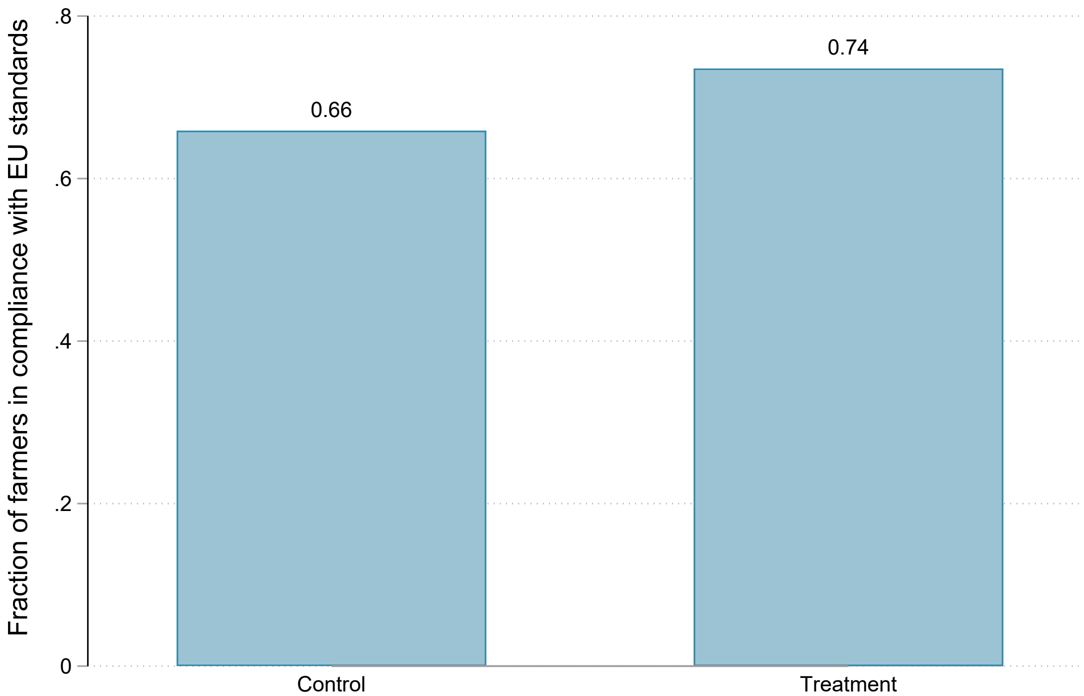
4.3 Quality

The quality measure we study is aflatoxin contamination. As described above in Section 3, we collected samples from farmers in the first six weeks of the commercialization season and tested them for aflatoxin. Our primary quality-related outcome of interest is whether or not farmers produced groundnuts in compliance with the strict European Union standards for aflatoxin contamination. Figure 3 shows that only 66% of control group farmers were in compliance with those standards, suggesting high incidence of contamination. This result is in line with results from agronomic trials conducted elsewhere in Senegal in the same year (see Figure B.1). The figure makes clear that contamination is less common in the treatment group, although there is still a non-trivial portion of farmers who provided a sample exhibiting at least some contamination in excess of EU standards.

In the absence of Aflasafe use, aflatoxin levels can vary significantly across space and time. Figure B.4 shows the distribution of test results, disaggregated by cooperative. Notably, the leftmost bars in that figure indicate the percentage of tests within each group that returned

[24]To rule out spatial spillovers in adoption, we estimate a regression specification similar to the one used in Miguel and Kremer (2004), in which we include the average treatment status or adoption decision in nearby villages. After controlling for a village's treatment status, these additional variables have no statistically significant effect on self-reported or admin data adoption.

Figure 3: Compliance with EU aflatoxin standards



a test result of less than 4 parts per billion (ppb), which is the strictest quality standard imposed by the European Union. This figure demonstrates that in our sample, aflatoxin levels were significantly higher for control farmers in the Northern cooperative than for those in the Southern cooperative.[25] Nevertheless, in both cooperatives more than 50% of control farmers had aflatoxin levels below 4 ppb. Bauchet et al. (2020) find similar results among maize samples collected in south-east Senegal, and Magnan et al. (2019) observe even lower average levels of contamination among groundnut samples in Ghana. Across two seasons, (Waliyar et al., 2015) find 35-41% of groundnut samples exhibited aflatoxin levels below 4 ppb at harvest in Mali.

We focus on a binary measure of quality standard compliance for two reasons. First, this is the most salient threshold for exporters, and therefore of particular importance for farmers and intermediaries seeking to access lucrative international markets. Second, our testing procedure has a minimum level of detection of 2 parts per billion (well below the EU quality standard). That is, any results below 2 only tell us that the sample was not contaminated, but do not tell us the exact level of aflatoxin detected. This does not affect our analysis of the EU cutoff, but does affect our analysis of the continuous outcome. Importantly, 160 out of 328 samples tested fall below 2 ppb, so this potentially impacts a large portion of our sample. We set any test results equal to the midpoint (1 ppb) if the recorded result was less

[25] Test results are winsorized above 100 ppb, the maximum level of detection from our testing equipment.

than or equal to 2 ppb.[26]

An additional issue with measuring the effects of the contract on quality is sample attrition. As mentioned above, for farmers who delivered output to the cooperative, we sampled that output to test for aflatoxin levels. However, with many farmers electing to sell no output to the cooperative, we had to adapt our data collection strategy to collect samples from these farmers. We offered a significant premium to purchase a 1 kg sample from all farmers, not only those who delivered output for sale to the cooperative. In the end, we collected samples from 83% of participating farmers.[27] Anecdotally, some farmers who did not deliver a sample experienced significant crop failure due to a challenging rainy season. Others, facing unusually high spot market prices at the start of the commercialization season, quickly sold their entire output before we re-contacted them to request a sample.

4.4 Commercialization Behavior

Finally, we consider farmers' commercialization decisions. As shown above in Table 1, at baseline farmers typically sold some output via the cooperatives and some output via other traders. Figure B.2 shows how farmers allocated their output across sales, consumption, and other uses at baseline and endline.[28] This figure suggests several notable features of our setting. First, as in Aflagah et al. (2019), we find that farmers allocate a large fraction of their output to commercial sale outside of their cooperatives, and only a small fraction to the cooperatives. Second, the fraction of output allocated to commercial sale, via the cooperative or otherwise, seems to have declined in the endline. Third, there is a small but important fraction of output that is kept for home consumption. This is particularly relevant given that consumption of aflatoxin-contaminated crops can affect health of adults and children. Similarly, farmers keep a fraction for seeds or giveaways.[29] Although the total fraction of output kept for seeds increased, the quantity in levels is relatively constant across the two years. This is due to significantly lower yields during the season we study relative to the baseline year.

We analyze two outcomes relevant to understanding farmers' commercialization decisions. Figure 4 summarizes dummy variables equal to one if a farmer sold any output to the cooperative or another buyer, kept any output for home consumption or seeds, or gave any output away to others. The key outcome is shown in the first column: output allocated

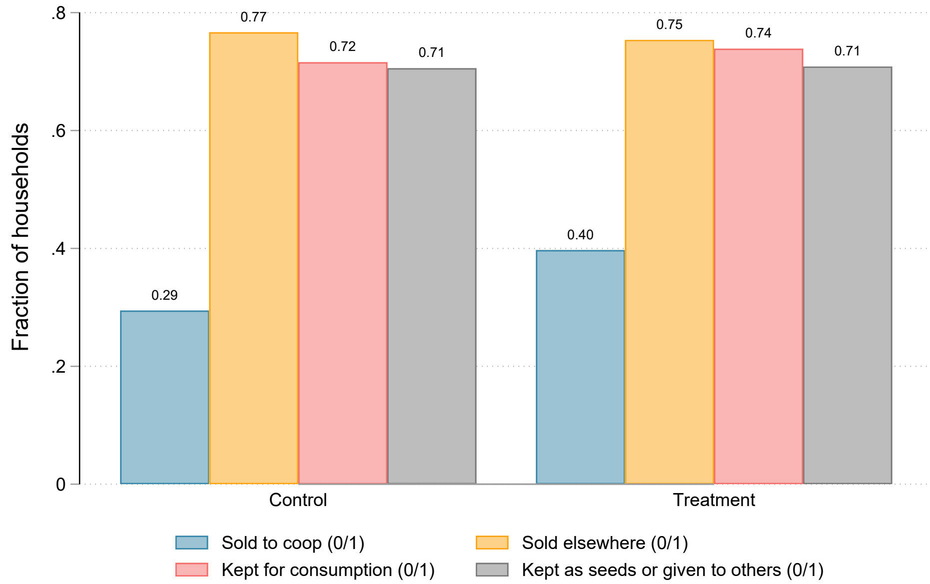
[26] In future work, we will explore multiple imputation methods to more fully account for the censoring among low-contamination samples.

[27] Note: Treated farmers were significantly less likely to deliver a sample for testing (11 percentage points) than control farmers. It is possible that treated farmers with particularly high quality were more easily able to sell their output for a high price on the spot market. Conversely, it is possible that treated farmers with particularly low quality did not wish to undergo quality certification for reputational reasons. In a future draft, we will use imputation techniques to bound treatment effect estimates on quality outcomes accounting for this differential attrition.

[28] Note: At endline, we additionally distinguished between keeping groundnuts as seeds or giving away to others.

[29] Groundnuts are often given to others as payment-in-kind for labor during the growing season.

(a) Baseline



(b) Endline

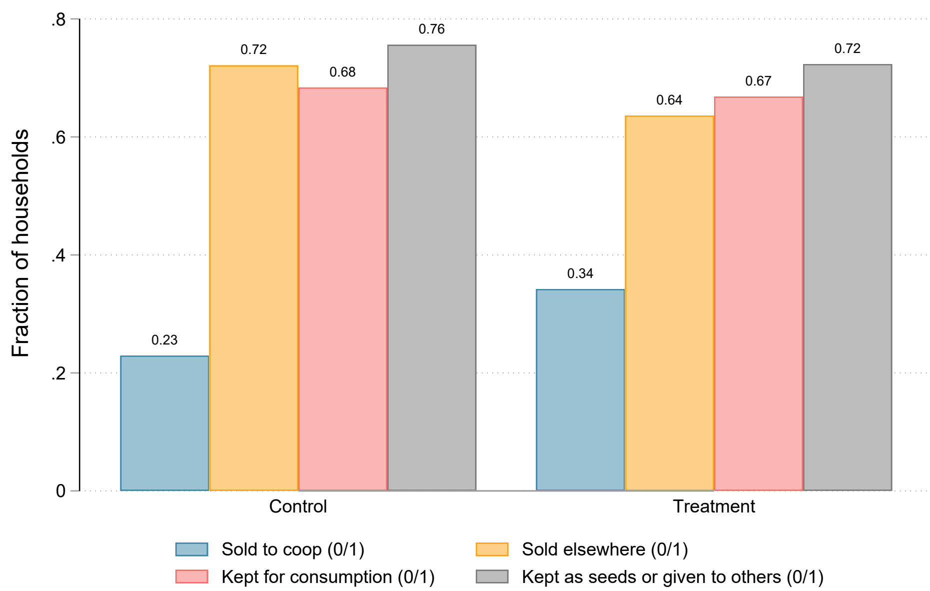


Figure 4: Output allocation dummies

to the cooperative. We see that farmers in the treated group are more likely to allocate any output to the cooperative. The difference at baseline is not statistically significant, although the difference in magnitudes is similar at baseline and endline. We also see that, across baseline and endline, likelihood of allocating output to other destinations is relatively constant both over time and across groups.

The second outcome is the quantity of output allocated to the cooperative. Figure B.3 shows the distribution of output allocation to the cooperative at baseline and endline. The leftmost bar shows farmers who allocated zero output to the cooperative. The distribution is highly skewed at both baseline and endline. Given these two facts, we analyze the inverse hyperbolic sine transformation of output allocated to the cooperative.

We also face some attrition in these outcomes. The endline survey was conducted by phone in June 2020, and some farmers were unable or unwilling to respond. We successfully surveyed 93% of the baseline sample, and attrition from the endline is not different by treatment status. Of the 7% who did not complete the endline survey, most were simply due to difficulty contacting the respondent by phone.

4.5 Climate data

To estimate the relationship between aflatoxin and growing season agro-climatic conditions, we use two sources of remotely-sensed data on precipitation and land surface temperature. For precipitation data, we rely on CHIRPS 2.0 daily rainfall estimates. For land surface temperature, we rely on the Copernicus LST10-DC dekadal land surface estimates. Both datasets have a 0.05° spatial resolution. We consider a "growing season" period defined by planting dates reported by farmers and the average time to harvest for the groundnut varieties common in our sample (90-110 days).

We define two village-level growing season variables: number of dry spells and average growing season daily max temperature. To define dry spells, we follow Bowen and Hagan (2015) who find that 3-day and 4-day dry spells are predictive of aflatoxin contamination. We calculate the cumulative number of dry spells experienced in each village during the growing season period. To define average growing season daily max temperature, we take the max temperature for each dekadal temperature estimate, and then take the mean of these values over the growing season. To match villages to the spatial datasets, we take the mean value of all pixels within a 1 kilometer radius of the village midpoint.[30]

5 Empirical Strategy

For our outcomes of interest we estimate the following equation via OLS:

$$Y_{ijk} = \alpha + \beta_1 T_{jk} + \delta \mathbf{X}_{ijk} + \gamma_k + \epsilon_{ijk} \tag{1}$$

[30] Ideally, we would match each plot's location directly to the raster files. However, we only observe plot locations for 27 farmers in our dataset who were randomly selected for inclusion in the "audit" survey described above. The median distance from the plot to the village centerpoint is 0.97 km, motivating our use of a 1km radius. All results presented are robust to using a larger radius.

where T_{jk} is the treatment assignment of village j in commune k, γ_k is a commune fixed effect, and standard errors ϵ_{ijk} are clustered at the village level.[31] We present results with and without baseline controls $\mathbf{X}_{ijk}$. Where appropriate, we also estimate the treatment effect on the treated via 2SLS where we instrument Aflasafe adoption by treatment status.

We additional estimate the following equation:

$$Y_{ijk} = \alpha + \beta_1 T_{jk} + \beta_2 (T_{jk} \times H_{ijk}) + \delta \mathbf{X}_{ijk} + \gamma_k + \epsilon_{ijk} \tag{2}$$

where H_{ijk} is a measure of heterogeneity. We consider spatial heterogeneity (by predicted aflatoxin risk), as well as heterogeneity by the value of the relationship to the cooperative, as proxied by baseline variables: lead farmer status, recent member status, farmer age, and whether or not the household keeps groundnuts for home consumption. Additionally, we consider heterogeneity across behavioral measures presented above in Table 1: risk aversion, patience, and reciprocity. We again cluster standard errors at the village level, and additionally bootstrap standard errors when we include the predicted aflatoxin risk dummy.

We prepared a pre-analysis plan (PAP) in the course of developing this project, which is registered with the AEA registry (AEARCTR-0006315).[32] We deviate from the PAP in three ways, which we describe here briefly and more fully below in Appendix A.1. First, we implemented this project with a single treatment group, without offering any "partial" contracts as originally planned. Second, we randomized treatment assignment at the village level, to facilitate implementation and minimize potential spillovers. Third, we pre-specified several behavioral hypotheses which are infeasible to test due to insufficient variation in our elicited measurements.

6 Results

In this section, we consider three main families of outcomes. First, we test whether the contract offer described in Section 3 increased adoption of Aflasafe, using the administrative and self-reported measures of adoption. Second, we estimate intent-to-treat (ITT) and treatment-effect-on-the-treated (TOT) effects on quality (aflatoxin standard compliance). Third, we estimate ITT and TOT effects on commercialization behavior (output sales to the cooperative). We discuss how relationship value and behavioral mechanisms interact with commercialization decisions. For each TOT regression, we present estimates in which we instrument for the administrative adoption measure in the main body of the text, and show comparable TOT estimates using self-reported adoption in Appendix B.

[31] We follow convention for cluster-randomized RCTs in clustering at the treatment assignment (village) level. However, some new work by de Chaisemartin and Ramirez-Cuellar (2020) suggests it may be more appropriate to cluster at the strata level when strata are small. We will explore clustering at the strata (commune) level in a future revision.

[32] The PAP was presented publicly at the Northwestern University GPRL Pre-Analysis Plan Mini-Conference in May 2019, before we began any project activities in the field. This un-modified document was only submitted to the AEA registry in August 2020.

6.1 Treatment Effects on Adoption

We first present results on the adoption of Aflasafe. Table 2 demonstrates the treatment had a remarkably large effect on farmers' adoption decisions by either measure of adoption. The treatment effect when we use the admin data is 79-80 percentage points, whereas the treatment effect using the self-reported outcome is 59-61 percentage points. These effects are robust to the inclusion of commune or cooperative FE and additional baseline controls described above in Table 1.

It is worth taking a moment to discuss the magnitude of these results. Because the treatment contract is a bundle including credit, our adoption measure nests credit uptake by treated farmers. Existing work on credit expansion typically finds low rates of credit adoption, in the range of 17-31% (Angelucci et al., 2015; Crépon et al., 2015; Tarozzi et al., 2015; Chowdhury et al., 2020). Similarly, existing work on credit expansion typically finds small impacts on technology adoption and input use (Crépon et al., 2015; Tarozzi et al., 2015; Beaman et al., 2020) or even no effect at all (Chowdhury et al., 2020; Nakano and Magezi, 2020).[33]

The bundled treatment additionally provided farmers certainty about receiving training on proper use of the technology.[34] Magnan et al. (2019) find information provision increases purchases of drying sheets for aflatoxin reduction by 9.7-14 percentage points. Training and farmer field days have been found to increase adoption of pest control practices and improved seeds by 12-15 percentage points (Emerick and Dar, 2020; Lerva, 2020).

Finally, the treatment provided farmers with increased price premium certainty upon adoption and proper use of the technology. Magnan et al. (2019) find no significant effect of a price premium on the purchase of a low-cost technology (drying sheets) for groundnut farmers. Arouna et al. (2019) find that a contract with only price certainty is insufficient to increase agricultural investment, although it can increase productivity. Karlan et al. (2011) test the impacts of crop-price indemnification embedded in agricultural lending, and find modest impacts on high-risk agricultural investment and on the probability of sale to higher-return buyers.

Our setting differs in several important ways from these past studies. First, we offer relatively small loans which are exclusively intended to finance adoption of the new technology. Second, the technology is not expected to increase yields. Instead, by increasing quality, farmers can expect to earn a higher price for their output. The contract we implemented offered treated farmers increased certainty that adoption would be profitable, conditional on quality certification. Profitability is an important element of agricultural technology adoption decisions (Michler et al., 2019). Third, farmers face non-pecuniary incentives to adopt the technology, since it can also have health impacts for farmers who consume some

[33] Along the same lines, relaxing credit and risk constraints via grants and index insurance has a significant but relatively small effect on input investment (Karlan et al., 2014; Bulte et al., 2019).

[34] All farmers received in-person assistance to apply the technology. The difference between treatment and control is in the ex-ante promise of a field visit.

of the groundnuts they grow.

Table 2: Aflasafe adoption

	Admin Data Adoption			Self-Reported Adoption		
	(1)	(2)	(3)	(4)	(5)	(6)
Treated	0.79***	0.79***	0.78***	0.59***	0.61***	0.60***
	(0.06)	(0.06)	(0.06)	(0.07)	(0.06)	(0.06)
Observations	396	396	396	370	370	370
R^2	0.621	0.649	0.676	0.347	0.378	0.430
Control Mean Dep. Var	0.10	0.10	0.10	0.20	0.20	0.20
Commune FE	N	Y	Y	N	Y	Y
Baseline controls	N	N	Y	N	N	Y

Results in this table are from linear regressions of the adoption dummy on the treatment dummy. Admin Data Adoption is measured using distribution logs and extension agent field visit logs, provided by our partner cooperatives. Self-Reported Adoption was elicited in the endline survey. Standard errors (in parentheses) are clustered at the treatment assignment (village cluster) level. Baseline controls included are all variables shown above in Table 1.

6.2 Treatment Effects on Quality

Next, we present results on quality. We consider two outcomes: EU phytosanitary standard compliance and a continuous measure of quality. Table 3 demonstrates the impact of the contract on phytosanitary compliance. We see that on average, the point estimate on standard compliance is positive but imprecisely estimated. However, given the significant spatial variation in aflatoxin levels among control farmers documented above in Section 4, this small average effect may disguise heterogeneous effects. Past research has demonstrated the potential for significant variation in contamination risk across space and time. In Ghana, Magnan et al. (2019) find substantial variation in aflatoxin levels in samples collected from the same farmers across three years, with 90 percent exceeding EU limits in one year and 7 percent exceeding those limits in the subsequent years.

We use spatial data on agro-climatic conditions during the growing season to estimate each village's average risk of aflatoxin contamination in the absence of the treatment. In line with previous work by Bowen and Hagan (2015), we identify two key predictors of aflatoxin contamination: dry spell incidence and average max temperature during the growing season. Using these two predictors, we proceed to estimate climate-induced aflatoxin risk in three steps. First, we estimate the relationship between the natural log of observed aflatoxin levels in control villages and our agro-climatic variables using LASSO and a simpler quadratic specification.[35] Second, using this estimated relationship between temperature, precipitation, and contamination, we predict village-level aflatoxin contamination risk for all villages in

[35]Results are robust to a variety of alternative specifications, such as including temperature or dry season bins.

our sample. Third, we generate a dummy variable for predicted "high-risk" villages where predicted average contamination exceeds EU phytosanitary standards. Columns (2) and (3) of table 3 show that we find consistently that the treatment effect is statistically significant and large in magnitude in villages predicted to be at high risk of aflatoxin contamination, and indistinguishable from zero in low-risk villages.[36]

As discussed above in Section 4, statistical analysis of the continuous measure of quality is complicated by the fact that 49 percent of test results returned an aflatoxin level below the minimum level of detection of the testing equipment (2 parts per billion). We show results in Table B.2, but caution the reader that these results may not be robust to more sophisticated methods of addressing the censored nature of the outcome. Nevertheless, the story is quite similar to the binary measure which suffers no such problem. We are again unable to detect a significant average treatment effect, although the point estimate is negative (suggesting lower contamination levels). However, when we allow the effect to differ by predicted contamination risk, we again find that the contract had a large and significant impact on quality in high-risk villages.

How does this result compare to other studies of quality upgrading? Magnan et al. (2019) is the closest comparable study, in which they offer farmers a low-cost technology (a tarp for drying groundnuts) and a price premium for improved quality. They find treatment effects of technology provision on EU standard compliance of 40-46%, with similar but less precise effects of a price premium.[37] If we define an analogous outcome, we find treatment effects on EU standard compliance of 22-57%.[38]

More broadly, this finding demonstrates an avenue for smallholder farmers to comply with international standards and access lucrative export markets. Compliance with phytosanitary standards is often quite costly for farmers (Asfaw et al., 2009), and changing standards have played a significant role in stymieing past attempts to link smallholders to export markets (Ashraf et al., 2009). We find that using a relatively cheap new technology—Aflasafe—farmers can significantly increase their likelihood of standards compliance when they otherwise would be at high risk of non-compliance. However, while necessary for export market access, standards compliance is not sufficient. Exporters are typically unwilling to work directly with small farmers. The second key to exporting is therefore output aggregation, which we

[36]Note: We observe similar patterns when we simply interact treatment with spatial fixed effects at the cooperative or commune level. Endline survey data on farmer practices suggests that differences in this treatment effect are not driven by differences in farmer practices. Table C.2 shows that there are no detectable differences in endline adoption of improved drying practices or improved storage technologies.

[37]Other work has focused on maize, another important crop in sub-Saharan Africa commonly affected by aflatoxin contamination. EU standards for aflatoxin in maize are slightly higher at 10ppb. Contamination risks may also differ from groundnuts. Providing farmers with training, hermetic storage bags, and drying tarps for maize has been found to increase EU standard compliance by 33-71% (Pretari et al., 2019; Bauchet et al., 2020).

[38]Macchiavello and Miquel-Florensa (2019) consider a very different setting—coffee cultivation—and find that a contract farming program focused on contract-induced upgrading along a variety of dimensions, with treatment effects of 2-25% depending on the outcome. In a non-agricultural context, Atkin et al. (2017) find linking rug-producing firms to export markets increases quality by 26%.

Table 3: Phytosanitary standard compliance

	(1)	(2)	(3)
Panel A: ITT estimates			
Treated	0.08	-0.09	-0.07
	(0.050)	(0.070)	(0.060)
Treated ×		0.53***	
Pred. high risk (LASSO)		(0.130)	
Treated ×			0.30**
Pred. high risk (quadratic)			(0.120)
Pred. high risk (LASSO)		-0.47***	
		(0.080)	
Pred. high risk (quadratic)			-0.34***
			(0.130)
Panel B: TOT estimates (admin data adoption)			
Adopted	0.10	-0.11	-0.10
	(0.060)	(0.080)	(0.110)
Adopted ×		0.60***	
Pred. high risk (LASSO)		(0.140)	
Adopted ×			0.40**
Pred. high risk (quadratic)			(0.160)
Pred. high risk (LASSO)		-0.54***	
		(0.110)	
Pred. high risk (quadratic)			-0.34***
			(0.130)
N	328	328	328
Control mean	0.659	0.659	0.659

This table shows results of regressions where the outcome variable is a dummy equal to one if the groundnut sample complied with EU phytosanitary standards. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Columns (2) and (3) include an interaction with a dummy equal to one if the village was predicted to be at high risk given agro-climatic conditions experienced during the growing season. See Appendix C for details. In panel B, the 2SLS regression additionally includes treatment interacted with the predicted high risk dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. See Table B.1 for a longer table including an additional measure of adoption and estimates including additional baseline controls.

discuss below.

6.3 Commercialization Behavior

Next, we consider the impact of the new contract on farmer commercialization behavior. This is an important outcome for policy (Barrett, 2008; Fischer and Qaim, 2012), as intermediaries and cooperatives would only be interested in implementing such a contract if they can aggregate a sufficient quantity of high-quality production. Despite recent work showing that even "cheap talk" signaling can improve output aggregation (Aflagah et al., 2019), this remains a major problem for cooperatives in Senegal and elsewhere. This outcome is also of academic interest. Given that the treatment represents a modification of the relational contract between farmers and cooperatives, it is useful to measure to what extent this change improves contract success by increasing output sales to the cooperative. In particular, given the high spot market prices in the season we study, the outcomes we observe here demonstrate the role of contract formalization in improving compliance when the temptation to cheat is high.

Table 5 shows the effect of the contract offer on output sales to the cooperative at the extensive margin. The outcome is a dummy equal to one if the farmer reported any output sales to the cooperative at endline. On average, treatment increased the probability of allocating any output to the cooperative by 13 percentage points. Results analyzing the intensive margin of output allocation, shown in Table B.4, tell a similar story.[39]

How do these findings compare to the literature? Aflagah et al. (2019) find that in larger village cooperative groups, a cheap talk intervention of sharing ex-ante collective commercialization intentions increased the probability of sales to the cooperative by 1 percentage point (13%) per group member, but do not detect an effect on average. By comparison, our point estimate suggests a 13 percentage point (56%) increase in the probability of sales to the cooperative.

[39]One interpretation of this intensive-margin result is that treated farmers simply sold enough extra output to the cooperative to repay their credit for purchasing Aflasafe. However, the magnitude of the average treatment effect is roughly double that of the cost of Aflasafe. Indeed this increase in output aggregation is sufficient to cover all of a cooperative's marginal costs if they were additionally paying for aflatoxin testing. Combined with the premium buyers are willing to pay cooperatives for certified high-quality production, we estimate a cooperative would more than break even given the magnitude of our results.

Table 4: Sold any output to coop, with behavioral heterogeneity

	(1)	(2)	(3)	(4)
Panel A: ITT estimates				
Treated	0.13**	-0.05	0.00	0.16***
	(0.050)	(0.080)	(0.090)	(0.060)
Treated × Reciprocal		0.38**		
		(0.160)		
Treated × Patient			0.16*	
			(0.100)	
Treated × Risk loving				-0.15
				(0.110)
Reciprocal	-0.05	-0.28**	-0.05	-0.05
	(0.110)	(0.110)	(0.110)	(0.110)
Patient	-0.01	-0.01	-0.09	0.00
	(0.050)	(0.050)	(0.070)	(0.050)
Risk loving	0.07	0.07	0.06	0.15**
	(0.050)	(0.050)	(0.050)	(0.070)
Panel B: TOT estimates (admin data adoption)				
Adopted	0.16***	-0.04	-0.01	0.20***
	(0.060)	(0.100)	(0.110)	(0.060)
Adopted × Reciprocal		0.41**		
		(0.190)		
Adopted × Patient			0.21*	
			(0.120)	
Adopted × Risk loving				-0.19
				(0.150)
Reciprocal	-0.07	-0.32**	-0.07	-0.06
	(0.100)	(0.120)	(0.100)	(0.100)
Patient	0.00	0.00	-0.11	0.00
	(0.050)	(0.050)	(0.080)	(0.050)
Risk loving	0.06	0.06	0.06	0.16*
	(0.050)	(0.050)	(0.050)	(0.090)
N	370	370	370	370
Control mean	0.230	0.230	0.230	0.230

This table shows results of regressions where the outcome variable is a dummy equal to one if the farmer reported selling any output to the cooperative. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Column (2) additionally includes an interaction with a continuous measure of reciprocity bounded in [0,1], column (3) includes an interaction with a dummy equal to one for self-assessed patient farmers, and column (4) includes an interaction with a dummy equal to one if the farmer identified as extremely willing to take risks. In panel B, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. All regressions include commune fixed effects to account for stratified randomization of treatment assignment. Standard errors are clustered at the treatment assignment (village) level. See Table B.7 for corresponding results using an additional measure of adoption and with additional baseline controls included.

6.3.1 Behavioral Mechanisms

Behavioral characteristics like reciprocity and patience can play important roles in the success of informal relationships (Leider et al., 2009; Finan and Schechter, 2012; Ligon and Schechter, 2012). Relationships between farmers and cooperatives are not purely commercial, as they also invoke a sense of collective action and solidarity among members. Understanding the behavioral mechanisms that drive increased collective commercialization could improve contract design or targeting. Table 4 shows that there is a significant and positive interaction between the treatment and a baseline measure of intrinsic reciprocity. The marginal effect of treatment is small or statistically indistinguishable from zero for low-reciprocity farmers. By comparison, for the most reciprocal farmers, the treatment increases output allocation to the cooperative by about 33 percentage points. These results are consistent with intrinisic or instrumental reciprocity affecting relational contract success (Sobel, 2005; Cabral et al., 2014). However, we are unable to separately measure intrinisic and instrumental reciprocity in this context.

Patience is also a key component of improving collective commercialization. Farmers who sell output to traders typically get paid immediately, in cash. By comparison, sales via the cooperative often involve a delay receiving some or all of the proceeds from the sale. The new contract may require additional patience, as quality-contingent premium payments require farmers to wait for results from an aflatoxin test. Column (3) of Table 4 demonstrates that the treatment effect was indeed larger for more patient farmers, although the effect is imprecise. These farmers may have been more willing to wait for the potential rewards associated with allocating output to the cooperative. The wording of the patience elicitation question are also suggestive: we asked farmers how they assessed their willingness to give up something today in order to benefit in the future. This may capture some element of instrumental reciprocity, in addition to the results on intrinisic reciprocity (Sobel, 2005; Cabral et al., 2014). Given that cooperatives may allocate access to new technologies and trials based on perceived reliability, it could be that the farmers we flag as more patient recognize this and respond accordingly.

By contrast, we fail to detect any evidence of heterogeneity by risk aversion. We define a dummy equal to one if a farmer reported above-median risk aversion on an 11-point scale, following Charness and Viceisza (2016). Failure to detect an outcome could indicate a need to better adapt risk measurement methods to our precise context. Alternatively, it could indicate that risk aversion does not impact the decision to sell output to the cooperative. This seems less likely, given that farmers who choose to sell output elsewhere risk reduced access to future benefits from the cooperative. However, this will be an avenue for additional study in our planned follow-up study.[40]

[40] We additionally tried to measure time inconsistency, altruism, and trust. Given the pilot nature of this project, we aimed to test measurements of a variety of behavioral mechanisms. For these measures in particular, we failed to capture any significant variation in responses. In future work, we will improve our measurement of these potential mechanisms to improve our understanding of their role in contract success.

Table 5: Sold any output to coop, with heterogeneity by relationship value

	(1)	(2)	(3)
Panel A: ITT estimates			
Treated	0.12**	0.07	0.09*
	(0.050)	(0.060)	(0.050)
Treated × Newer member		0.18*	
		(0.100)	
Treated × Lead farmer			0.19*
			(0.110)
Newer member	-0.05	-0.13*	-0.05
	(0.050)	(0.060)	(0.050)
Lead farmer	0.18***	0.18***	0.07
	(0.050)	(0.050)	(0.090)
Panel B: TOT estimates (admin data adoption)			
Adopted	0.15**	0.09	0.12**
	(0.060)	(0.070)	(0.060)
Adopted × Newer member		0.21*	
		(0.120)	
Adopted × Lead farmer			0.20
			(0.150)
Newer member	-0.04	-0.14*	-0.04
	(0.040)	(0.070)	(0.050)
Lead farmer	0.18***	0.18***	0.06
	(0.050)	(0.050)	(0.110)
N	370	370	370
Control mean	0.230	0.230	0.230

This table shows results of regressions where the outcome variable is a dummy equal to one if the farmer reported selling any output to the cooperative. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Column (2) additionally includes an interaction with a dummy equal to one if the farmer joined the cooperative recently (defined as joining in the two years before the study began), and column (3) includes an interaction with a dummy equal to one if the farmer reported helping the cooperative as a lead farmer. In panel B, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. All regressions include commune fixed effects to account for stratified randomization of treatment assignment. Standard errors are clustered at the treatment assignment (village) level. See Table B.3 for corresponding results using an additional measure of adoption and with additional baseline controls included.

6.3.2 Relationship Value

Previous work in the literature has demonstrated the role of relationship value in relational contracting (Macchiavello and Morjaria, 2015). Here we examine this question using baseline variables suggestive of the value a farmer might place on their relationship to the cooperative. Each variable captures a slightly different aspect of value. The first is defined based on the year the farmer joined the cooperative. If newer farmers need to sell output to the cooperative to establish reputation, and the new contract increases the perceived expectation of output sales, then the treatment may be particularly effective for these farmers at inducing changes in commercialization behavior. If instead newer farmers have invested less in the relationship with the cooperative, and so perceive it as less costly to lose the relationship, they may be less impacted by the treatment. As Table 5 shows, we find a positive interaction between treatment and newer member status. Given that farmers are typically geographically constrained in the cooperatives they can plausibly join, this result suggests that newer farmers may seek to signal reliability to continue receiving access to credit for inputs and an avenue for output sales.[41]

The second aspect of relationship value is leadership status in the cooperative. Our partner cooperatives work with a set of lead farmers in participating villages. In many agricultural extension contexts, lead farmers serve to demonstrate and test new technologies, as well as diffusing information about agricultural practices to the communities (Kondylis et al., 2017). Lead farmers also derive substantial benefits from their status, in the form of earlier access to new technologies and information. For these reasons, we might expect that lead farmers would be more likely to comply with a new contract in order to maintain access to Aflasafe or be considered for future trials. Indeed, we find suggestive evidence of this result in Table 5, although the effect is imprecisely estimated and not statistically significant in some specifications.

An additional aspect of the value of the relationship hinges more specifically on the potential health benefits of reducing aflatoxin exposure. This may be particularly salient for younger farmers, for whom earlier reductions in chronic exposure could have compounding benefits, as well as for farmers who reported keeping some of their groundnut production for home consumption at baseline. We test these hypotheses in Table 6. We find that the treatment effect is significantly smaller for older farmers, and significantly larger for farmers who consume some of their production. Measuring and quantifying the value of these health benefits in driving technology adoption and changes in commercialization behavior may be a fruitful avenue for future work.

[41] One alternative explanation consistent with this evidence is that newer members are more "active" in general. These cooperatives formed (or re-formed) recently under the umbrella of a new national network of cooperatives. Members who joined in the earliest year may have simply been added to membership rolls en masse, whereas newer members may have actively sought out membership. However, given the noisy but negative point estimate we detect on average, it seems that newer members are less likely in general—or in the absence of our contract—to deliver output to the cooperative.

Table 6: Sold any output to coop, with heterogeneity by age and baseline consumption

	(1)	(2)	(3)
Panel A: ITT estimates			
Treated	0.12**	0.42***	-0.07
	(0.050)	(0.150)	(0.080)
Treated × Age at baseline		-0.01**	
		(0.000)	
Treated × Consumes some production			0.25***
			(0.090)
Age at baseline	0.00	0.00	0.00
	(0.000)	(0.000)	(0.000)
Consumes some production	0.07	0.06	-0.06
	(0.050)	(0.050)	(0.070)
Panel B: TOT estimates (admin data adoption)			
Adopted	0.15***	0.52***	-0.09
	(0.060)	(0.170)	(0.090)
Adopted × Age at baseline		-0.01**	
		(0.000)	
Adopted × Consumes some production			0.32***
			(0.110)
Age at baseline	0.00	0.00	0.00
	(0.000)	(0.000)	(0.000)
Consumes some production	0.07	0.07	-0.10
	(0.050)	(0.050)	(0.080)
N	370	370	370
Control mean	0.230	0.230	0.230

This table shows results of regressions where the outcome variable is a dummy equal to one if the farmer reported selling any output to the cooperative. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Column (2) additionally includes an interaction with the reported age of the baseline respondent, and column (3) includes an interaction with a dummy equal to one if the farmer reported at baseline keeping any groundnut production for home consumption. In panel B, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. All regressions include commune fixed effects to account for stratified randomization of treatment assignment. Standard errors are clustered at the treatment assignment (village) level. See Table B.5 for corresponding results using an additional measure of adoption and with additional baseline controls included.

7 Discussion

In this paper, we present new evidence that a simple contracting arrangement can induce improvements in crop quality via the adoption of a new technology. Adoption of this technology in areas where quality is otherwise low produce significantly higher-quality groundnuts. The contracting arrangement improves commercial outcomes at cooperatives, with treatment effects concentrated among newer cooperative members, farmers who consume their production, and farmers who are more reciprocal and patient. These findings have important implications for contract design, particularly in environments with low enforcement capabilities.

Our work suggests several avenues for further research, which we intend to pursue in planned follow-up experiments.[42] In particular, although the bundled contract was highly effective at increasing Aflasafe adoption and did improve quality in high-risk areas, implementation of a comprehensive contract is costly. Could a cheaper contract with fewer contract elements provide similar benefits? To answer this question, we plan to extend and replicate our experiment with cross-randomized contract terms. Additionally, given the prominent role of traders and side-selling in this market, we plan to undertake complementary measurement exercises in local markets to quantify possible general equilibrium effects of our contracts, including changes in the quality composition of groundnuts traded in markets.

[42] With the arrival of COVID-19 in Senegal, we were forced to suspend field operations and the implementation of these planned follow-up experiments. We expect to resume implementation once field activities can safely resume.

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A Additional detail on design and experimental context

A.1 Pre-Specified Analysis

In the interest of transparency, we describe here several ways in which our analysis deviates from the pre-specified analysis, and why. We feel these changes are justified given the deviations in design and implementation from the PAP, but readers are invited to draw their own conclusions and judge our results accordingly.

First, the PAP covered a planned larger trial, featuring multiple treatment groups with both partial and full contracts. After writing this PAP and preparing to launch the project in the field, we decided to simplify the design to include a single treatment group covering the "full contract" described in the PAP. We reasoned this would allow us to demonstrate an upper bound on the treatment effects we might expect from partial contracts, as well as establishing working relationships with our implementation partners. We planned to implement the full design discussed in the PAP in the second year of the project, but this second phase has been delayed due to COVID-19.

Second, the PAP hinged on an individually-randomized trial. Upon finalizing our partnerships with two groundnut cooperatives, we learned more about the village-centered way they organize their existing field activities, including distribution of seeds and other inputs on credit. We decided that following this model in our project would significantly facilitate project implementation. More importantly, following this model allowed us to test an intervention which is feasible for our partner cooperatives to implement themselves within their existing model. Additionally, a cluster-randomized trial minimizes the potential for spillovers because both aflatoxin contamination and any potential effects of Aflasafe can impact neighboring fields.

Finally, we modify our empirical strategy given that the trial as implemented included only one treatment and was randomized at the village level. In particular, we are unable to implement our planned strategy for low variation in aflatoxin levels among non-treated farmers, which was to exclude villages with sufficiently low levels of aflatoxin among control farmers. Instead, we test for spatial heterogeneity by interacting treatment status with spatial dummies at cooperative and commune levels. We also pre-specified a number of behavioral mechanisms we would test. Some of these hypotheses are redundant given the simplified treatment. Some are also fruitless to test because our baseline measurements were unable to capture sufficient variation. We discuss some of the issues with baseline measurement above in Section 4.[43]

B Additional tables and figures

[43] Due to the pilot nature of this project, we tested a variety of measurement techniques for behavioral variables of interest. This will allow us to improve our measurement for the larger-scale project and test behavioral mechanisms more effectively.

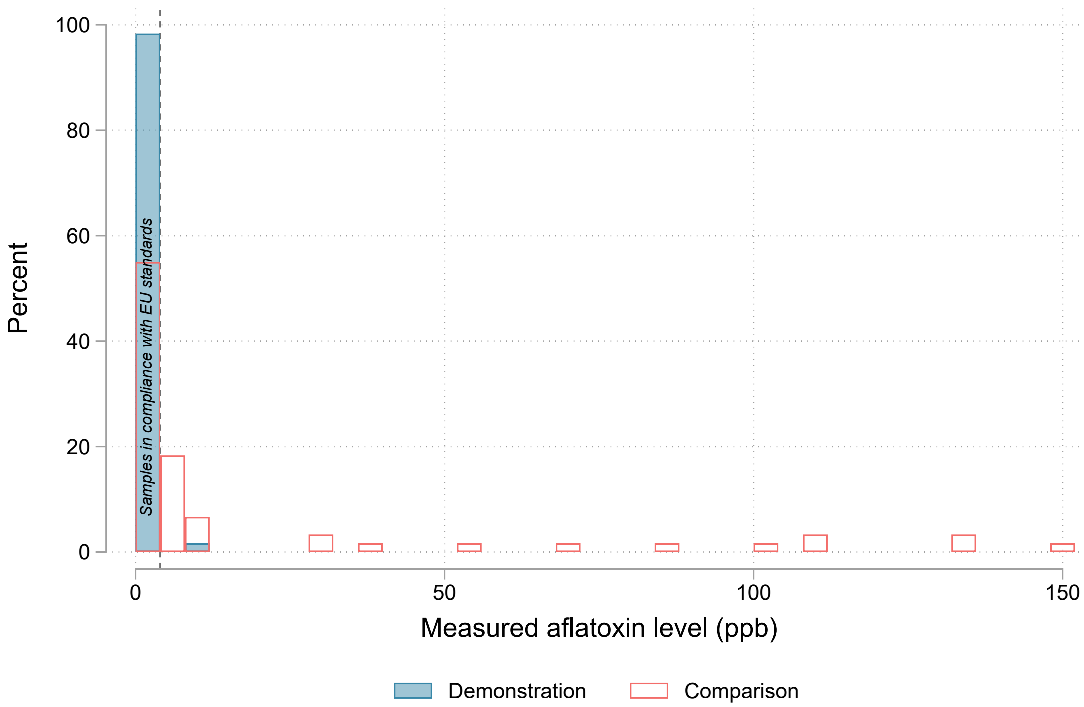
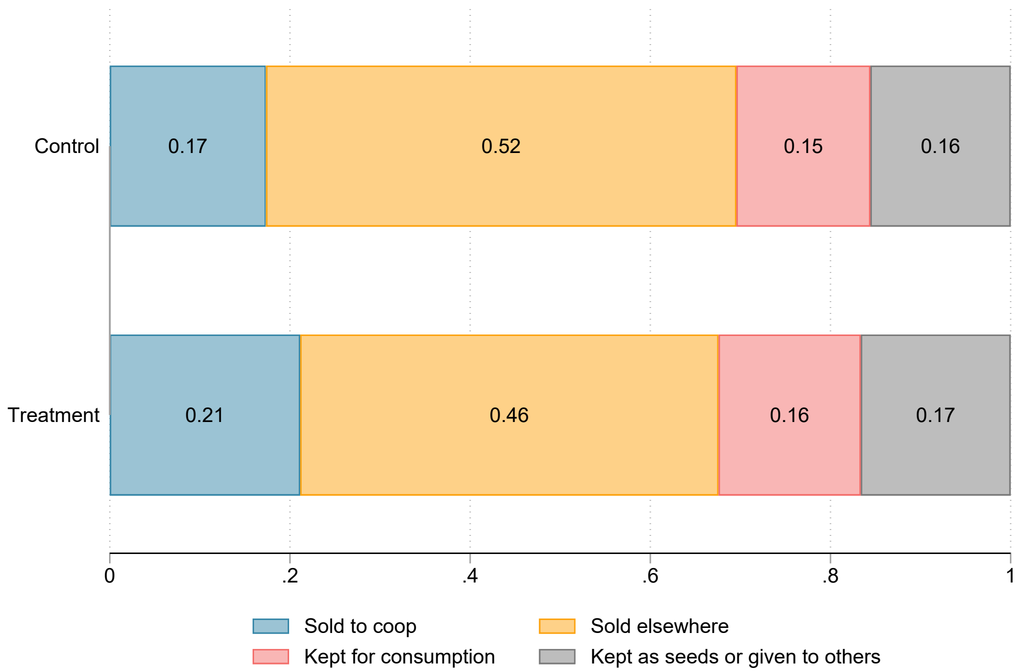


Figure B.1: Distribution of test results from IITA agronomic trials in 2019

B.1 More on baseline and endline data

(a) Baseline



(b) Endline

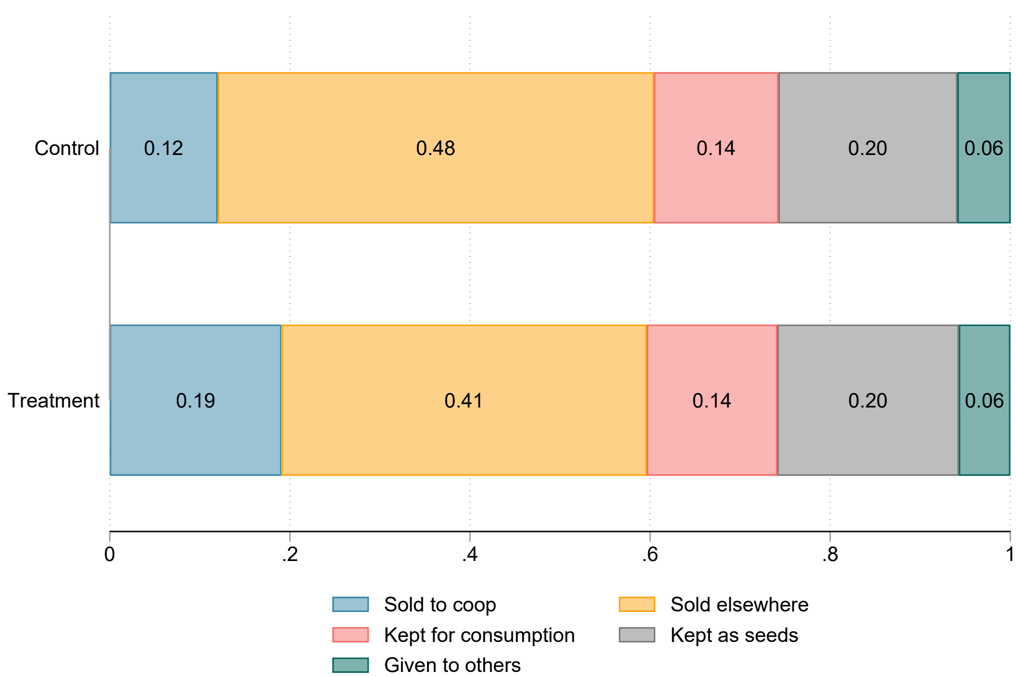
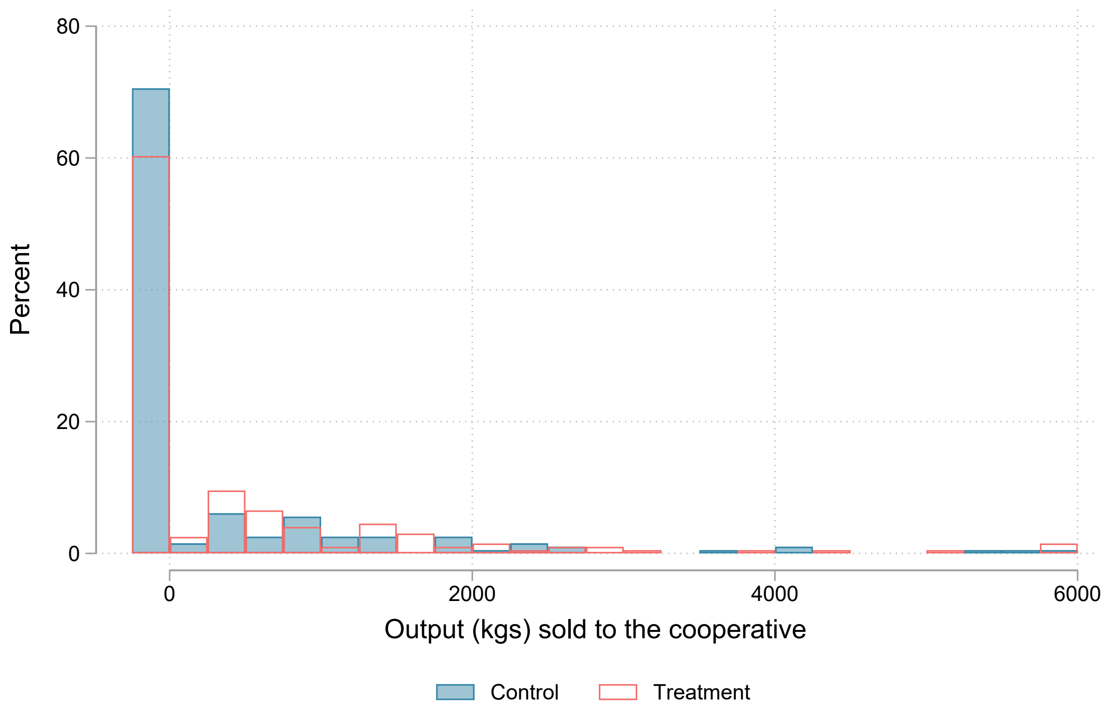


Figure B.2: Output allocation

(a) Baseline



(b) Endline

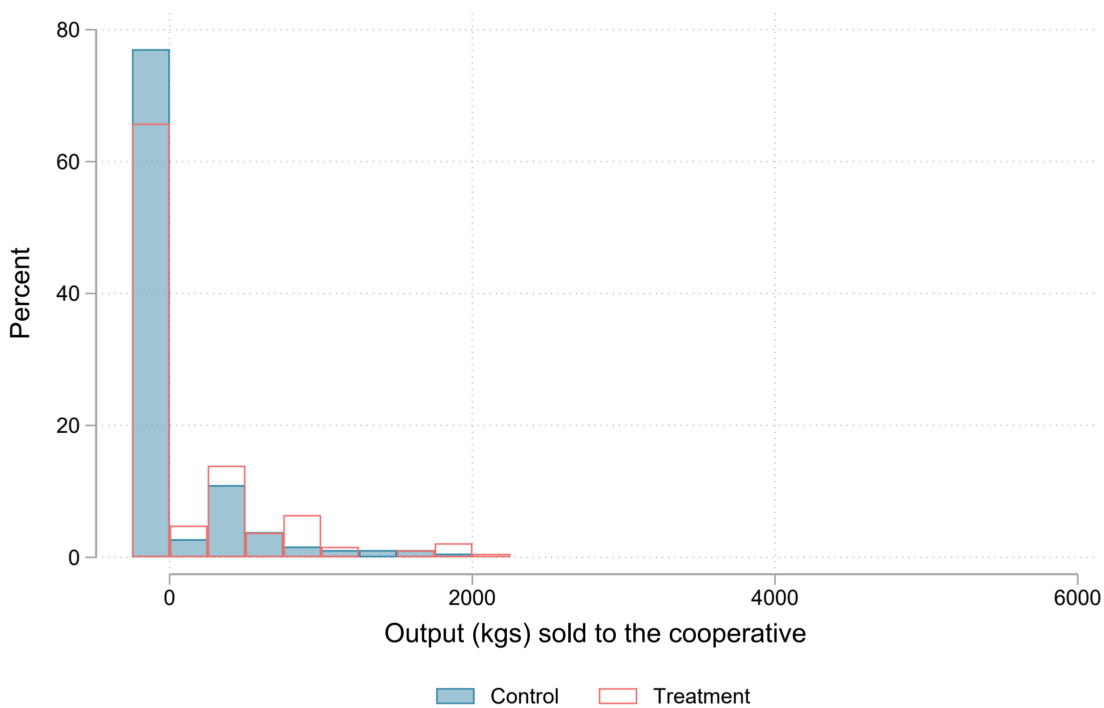
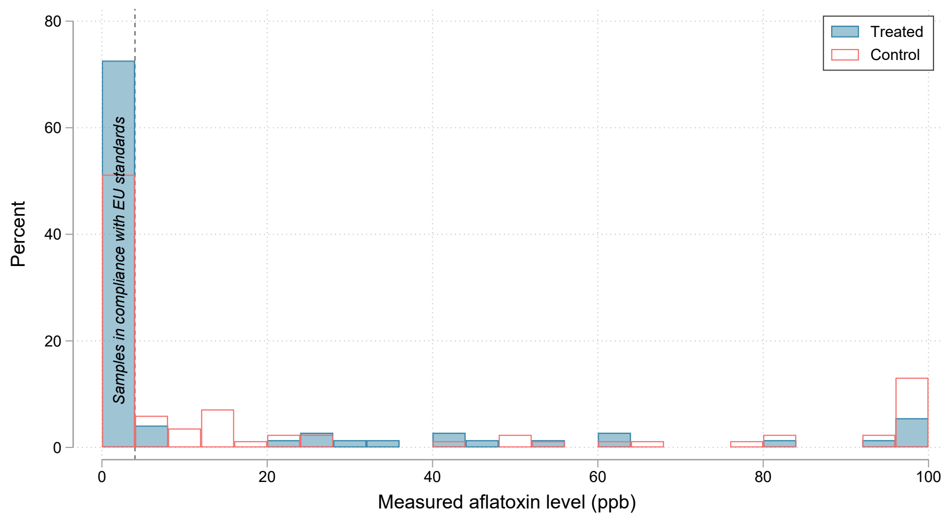


Figure B.3: Output allocation to the cooperative (kgs)

(a) Northern cooperative



(b) Southern cooperative

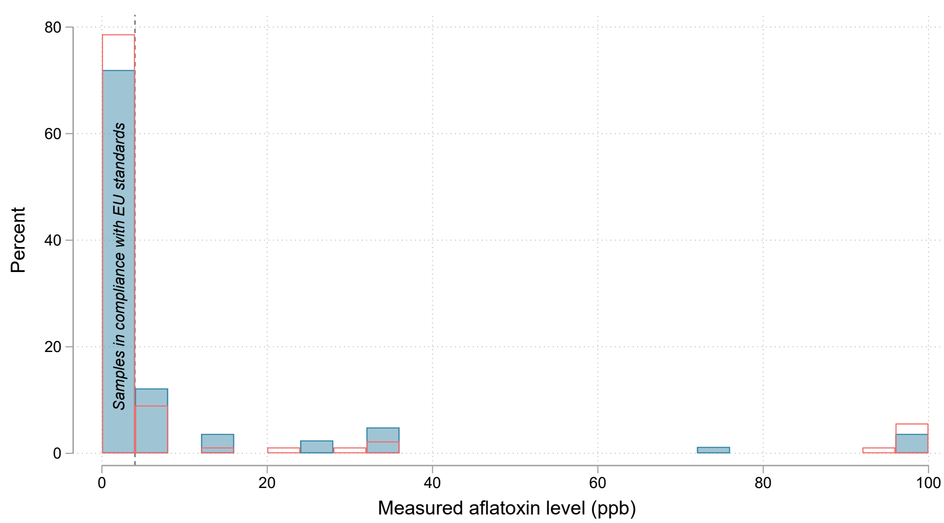


Figure B.4: Post-harvest aflatoxin levels

B.2 Additional results tables

Table B.1: Phytosanitary standard compliance

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ITT estimates						
Treated	0.08	0.09*	-0.09	-0.08	-0.07	-0.05
	(0.050)	(0.050)	(0.070)	(0.070)	(0.060)	(0.070)
Treated ×			0.53***	0.54***		
Pred. high risk (LASSO)			(0.130)	(0.130)		
Treated ×					0.30**	0.27*
Pred. high risk (quadratic)					(0.120)	(0.150)
Pred. high risk (LASSO)			-0.47***	-0.45***		
			(0.080)	(0.110)		
Pred. high risk (quadratic)					-0.34***	-0.30***
					(0.130)	(0.110)
Baseline controls	N	Y	N	Y	N	Y
N	328	328	328	328	328	328
Panel B: TOT estimates (admin data adoption)						
Adopted	0.10	0.11**	-0.11	-0.10	-0.10	-0.07
	(0.060)	(0.060)	(0.080)	(0.110)	(0.110)	(0.080)
Adopted ×			0.60***	0.60***		
Pred. high risk (LASSO)			(0.140)	(0.170)		
Adopted ×					0.40**	0.37*
Pred. high risk (quadratic)					(0.160)	(0.190)
Pred. high risk (LASSO)			-0.47***	-0.45***		
			(0.080)	(0.110)		
Pred. high risk (quadratic)					-0.34***	-0.30***
					(0.130)	(0.110)
Baseline controls	N	Y	N	Y	N	Y
N	328	328	328	328	328	328
Panel C: TOT estimates (self-reported adoption)						
Adopted	0.14*	0.15**	-0.14	-0.11	-0.09	-0.06
	(0.080)	(0.070)	(0.130)	(0.200)	(0.090)	(0.100)
Adopted ×			0.87**	0.86*		
Pred. high risk (LASSO)			(0.350)	(0.460)		
Adopted ×					0.58	0.54
Pred. high risk (quadratic)					(0.500)	(0.670)
Pred. high risk (LASSO)			-0.47***	-0.45***		
			(0.080)	(0.110)		
Pred. high risk (quadratic)					-0.34***	-0.30***
					(0.130)	(0.110)
Baseline controls	N	Y	N	Y	N	Y
N	307	307	307	307	307	307
Control mean	0.659	0.659	0.659	0.659	0.659	0.659

This table shows results of regressions where the outcome variable is a dummy equal to one if the groundnut sample complied with EU phytosanitary standards. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Panel C presents 2SLS results where adoption (as reported in the endline survey) is instrumented by treatment status. Columns (3) and (4) additionally include an interaction with the cooperative dummy. Columns (5) and (6) include an interaction with a dummy equal to one if the village was predicted to be at high risk given agro-climatic conditions experienced during the growing season. See Appendix C for details. In panels B and C, the 2SLS regressions additionally include treatment interacted with the cooperative dummy or the predicted high risk dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. Baseline controls included are all variables shown above in Table 1

Table B.2: Natural log of measured aflatoxin contamination levels

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ITT estimates						
Treated	-0.22	-0.20	0.40	0.40	0.26	0.20
	(0.200)	(0.170)	(0.250)	(0.290)	(0.240)	(0.250)
Treated × Pred. high risk (LASSO)			-1.90***	-2.01***		
			(0.400)	(0.460)		
Treated × Pred. high risk (quadratic)					-0.98*	-0.90*
					(0.510)	(0.490)
Pred. high risk (LASSO)			1.83***	1.96***		
			(0.260)	(0.380)		
Pred. high risk (quadratic)					1.00**	0.79**
					(0.450)	(0.390)
Baseline controls	N	Y	N	Y	N	Y
N	328	328	328	328	328	328
Panel B: TOT estimates (admin data adoption)						
Adopted	-0.27	-0.26	0.51	0.51	0.35	0.27
	(0.240)	(0.200)	(0.320)	(0.330)	(0.230)	(0.340)
Adopted × Pred. high risk (LASSO)			-2.17***	-2.26***		
			(0.470)	(0.530)		
Adopted × Pred. high risk (quadratic)					-1.29**	-1.22*
					(0.610)	(0.720)
Pred. high risk (LASSO)			1.83***	1.96***		
			(0.260)	(0.380)		
Pred. high risk (quadratic)					1.00**	0.79**
					(0.450)	(0.390)
Baseline controls	N	Y	N	Y	N	Y
N	328	328	328	328	328	328
Panel C: TOT estimates (self-reported adoption)						
Adopted	-0.35	-0.34	0.66*	0.64*	0.48	0.40
	(0.320)	(0.260)	(0.350)	(0.380)	(0.430)	(0.460)
Adopted × Pred. high risk (LASSO)			-3.07***	-3.17***		
			(0.670)	(0.710)		
Adopted × Pred. high risk (quadratic)					-2.19	-2.06
					(2.120)	(1.790)
Pred. high risk (LASSO)			1.83***	1.96***		
			(0.260)	(0.380)		
Pred. high risk (quadratic)					1.00**	0.79**
					(0.450)	(0.390)
Baseline controls	N	Y	N	Y	N	Y
N	307	307	307	307	307	307
Control mean	1.304	1.304	1.304	1.304	1.304	1.304

This table shows results of regressions where the outcome variable is the natural log of the measured aflatoxin contamination (in parts per billion) in the tested groundnut sample. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Panel C presents 2SLS results where adoption (as reported in the endline survey) is instrumented by treatment status. Columns (3) and (4) additionally include an interaction with the cooperative dummy. Columns (5) and (6) include an interaction with a dummy equal to one if the village was predicted to be at high risk given agro-climatic conditions experienced during the growing season. See Appendix C for details. In panels B and C, the 2SLS regressions additionally include treatment interacted with the cooperative dummy or the predicted high risk dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. Baseline controls included are all variables shown above in Table 1

Table B.3: Sold any output to coop, with heterogeneity by relationship value

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ITT estimates						
Treated	0.12**	0.10**	0.07	0.05	0.09*	0.08
	(0.050)	(0.050)	(0.060)	(0.060)	(0.050)	(0.050)
Treated ×			0.18*	0.19*		
Newer member			(0.100)	(0.100)		
Treated ×					0.19*	0.18
Lead farmer					(0.110)	(0.130)
Newer member	-0.05	-0.06	-0.13*	-0.14**	-0.05	-0.06
	(0.050)	(0.050)	(0.060)	(0.060)	(0.050)	(0.050)
Lead farmer	0.18***	0.17**	0.18***	0.17**	0.07	0.06
	(0.050)	(0.070)	(0.050)	(0.070)	(0.090)	(0.110)
Panel B: TOT estimates (admin data adoption)						
Adopted	0.15**	0.13**	0.09	0.06	0.12**	0.10*
	(0.060)	(0.050)	(0.070)	(0.070)	(0.060)	(0.060)
Adopted ×			0.21*	0.23**		
Newer member			(0.120)	(0.120)		
Adopted ×					0.20	0.19
Lead farmer					(0.150)	(0.150)
Newer member	-0.04	-0.05	-0.14*	-0.15**	-0.04	-0.05
	(0.040)	(0.050)	(0.070)	(0.060)	(0.050)	(0.050)
Lead farmer	0.18***	0.17**	0.18***	0.17**	0.06	0.06
	(0.050)	(0.070)	(0.050)	(0.060)	(0.110)	(0.120)
Panel C: TOT estimates (self-reported adoption)						
Adopted	0.19**	0.16**	0.11	0.07	0.15**	0.13*
	(0.080)	(0.070)	(0.090)	(0.090)	(0.080)	(0.070)
Adopted ×			0.37**	0.40**		
Newer member			(0.180)	(0.170)		
Adopted ×					0.42	0.37
Lead farmer					(0.270)	(0.270)
Newer member	-0.03	-0.04	-0.18**	-0.21**	-0.03	-0.04
	(0.040)	(0.040)	(0.090)	(0.090)	(0.040)	(0.050)
Lead farmer	0.16***	0.15**	0.15***	0.15**	-0.10	-0.08
	(0.060)	(0.070)	(0.060)	(0.070)	(0.170)	(0.180)
Baseline controls	N	Y	N	Y	N	Y
N	370	370	370	370	370	370
Control mean	0.230	0.230	0.230	0.230	0.230	0.230

This table shows results of regressions where the outcome variable is a dummy equal to one if the farmer reported selling any output to the cooperative. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Panel C presents 2SLS results where adoption (as reported in the endline survey) is instrumented by treatment status. Columns (3) and (4) additionally include an interaction with a dummy equal to one if the farmer joined the cooperative recently (defined as joining in the two years before the study began), and columns (5) and (6) include an interaction with a dummy equal to one if the farmer reported helping the cooperative as a lead farmer. In panels B and C, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. Baseline controls included are all variables shown above in Table 1

Table B.4: Quantity sold to coop, with heterogeneity by relationship value

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ITT estimates						
Treated	0.72	0.59	0.22	0.15	0.49	0.39
	(0.450)	(0.430)	(0.530)	(0.530)	(0.420)	(0.410)
Treated ×			1.96**	1.76**		
Newer member			(0.730)	(0.740)		
Treated ×					1.91**	1.79*
Lead farmer					(0.930)	(1.020)
Newer member	-0.26	-0.35	-1.11**	-1.09**	-0.23	-0.31
	(0.410)	(0.400)	(0.510)	(0.510)	(0.410)	(0.400)
Lead farmer	1.13**	0.97*	1.15**	1.00*	0.01	-0.10
	(0.460)	(0.540)	(0.450)	(0.540)	(0.710)	(0.880)
Panel B: TOT estimates (admin data adoption)						
Adopted	0.91	0.75	0.28	0.20	0.63	0.49
	(0.550)	(0.520)	(0.670)	(0.640)	(0.520)	(0.500)
Adopted ×			2.30**	2.06**		
Newer member			(0.930)	(0.870)		
Adopted ×					2.13*	2.00*
Lead farmer					(1.140)	(1.160)
Newer member	-0.24	-0.32	-1.34**	-1.28**	-0.22	-0.31
	(0.400)	(0.390)	(0.610)	(0.580)	(0.420)	(0.390)
Lead farmer	1.14**	0.98*	1.14**	1.00*	-0.07	-0.19
	(0.470)	(0.540)	(0.460)	(0.530)	(0.820)	(0.940)
Panel C: TOT estimates (self-reported adoption)						
Adopted	1.23	1.00	0.38	0.22	0.82	0.64
	(0.760)	(0.690)	(0.870)	(0.810)	(0.690)	(0.650)
Adopted ×			3.56***	3.31***		
Newer member			(1.300)	(1.260)		
Adopted ×					4.10**	3.80*
Lead farmer					(1.950)	(1.990)
Newer member	-0.21	-0.29	-1.77**	-1.71**	-0.21	-0.30
	(0.390)	(0.380)	(0.760)	(0.720)	(0.400)	(0.390)
Lead farmer	1.03**	0.90*	0.96**	0.88*	-1.49	-1.48
	(0.460)	(0.530)	(0.460)	(0.520)	(1.210)	(1.330)
Baseline controls	N	Y	N	Y	N	Y
N	370	370	370	370	370	370
Control mean	0.230	0.230	0.230	0.230	0.230	0.230

This table shows results of regressions where the outcome variable is the inverse hyperbolic sine transformation of groundnut output (in kgs) sold to the cooperative.. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Panel C presents 2SLS results where adoption (as reported in the endline survey) is instrumented by treatment status. Columns (3) and (4) additionally include an interaction with a dummy equal to one if the farmer joined the cooperative recently (defined as joining in the two years before the study began), and columns (5) and (6) include an interaction with a dummy equal to one if the farmer reported helping the cooperative as a lead farmer. In panels B and C, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. Baseline controls included are all variables shown above in Table 1

Table B.5: Sold any output to coop, with heterogeneity by age and baseline consumption

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ITT estimates						
Treated	0.12**	0.10**	0.42***	0.47***	-0.07	-0.11
	(0.050)	(0.050)	(0.150)	(0.150)	(0.080)	(0.080)
Treated × Age at baseline			-0.01**	-0.01**		
			(0.000)	(0.000)		
Treated × Consumes some production					0.25***	0.29***
					(0.090)	(0.090)
Age at baseline	0.00	0.00	0.00	0.00	0.00	0.00
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Consumes some production	0.07	0.03	0.06	0.03	-0.06	-0.11
	(0.050)	(0.050)	(0.050)	(0.050)	(0.070)	(0.070)
Panel B: TOT estimates (admin data adoption)						
Adopted	0.15***	0.13**	0.52***	0.58***	-0.09	-0.14
	(0.060)	(0.050)	(0.170)	(0.170)	(0.090)	(0.100)
Adopted × Age at baseline			-0.01**	-0.01***		
			(0.000)	(0.000)		
Adopted × Consumes some production					0.32***	0.37***
					(0.110)	(0.120)
Age at baseline	0.00	0.00	0.00	0.00	0.00	0.00
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Consumes some production	0.07	0.04	0.07	0.03	-0.10	-0.15*
	(0.050)	(0.050)	(0.050)	(0.050)	(0.080)	(0.080)
Panel C: TOT estimates (self-reported adoption)						
Adopted	0.19**	0.16**	0.85***	0.94***	-0.11	-0.18
	(0.080)	(0.070)	(0.270)	(0.250)	(0.110)	(0.120)
Adopted × Age at baseline			-0.01***	-0.02***		
			(0.000)	(0.000)		
Adopted × Consumes some production					0.44***	0.50***
					(0.140)	(0.150)
Age at baseline	0.00	0.00	0.00	0.01**	0.00	0.00
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Consumes some production	0.07	0.04	0.05	0.02	-0.16*	-0.21**
	(0.050)	(0.050)	(0.050)	(0.060)	(0.090)	(0.090)
Baseline controls	N	Y	N	Y	N	Y
N	370	370	370	370	370	370
Control mean	0.230	0.230	0.230	0.230	0.230	0.230

This table shows results of regressions where the outcome variable is a dummy equal to one if the farmer reported selling any output to the cooperative. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Panel C presents 2SLS results where adoption (as reported in the endline survey) is instrumented by treatment status. Columns (3) and (4) additionally include an interaction with the reported age of the baseline respondent, and columns (5) and (6) include an interaction with a dummy equal to one if the farmer reported at baseline keeping any groundnut production for home consumption. In panels B and C, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. Baseline controls included are all variables shown above in Table 1

Table B.6: Quantity sold to coop, with heterogeneity by age and baseline consumption

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: ITT estimates						
Treated	0.82**	0.67**	3.33***	3.73***	-0.45	-0.75
	(0.330)	(0.320)	(1.090)	(1.140)	(0.530)	(0.590)
Treated ×			-0.05**	-0.06***		
Age at baseline			(0.020)	(0.020)		
Treated ×					1.72***	1.93***
Consumes some production					(0.610)	(0.640)
Age at baseline	-0.01	-0.01	0.01	0.02	-0.01	-0.01
	(0.010)	(0.010)	(0.020)	(0.020)	(0.010)	(0.010)
Consumes some production	0.52	0.24	0.48	0.20	-0.34	-0.71
	(0.340)	(0.390)	(0.330)	(0.380)	(0.500)	(0.500)
Panel B: TOT estimates (admin data adoption)						
Adopted	1.03***	0.85**	4.11***	4.60***	-0.57	-0.96
	(0.390)	(0.370)	(1.250)	(1.250)	(0.640)	(0.710)
Adopted ×			-0.06***	-0.08***		
Age at baseline			(0.020)	(0.020)		
Adopted ×					2.20***	2.50***
Consumes some production					(0.760)	(0.810)
Age at baseline	-0.01	-0.01	0.02	0.02	-0.01	-0.01
	(0.010)	(0.010)	(0.020)	(0.020)	(0.010)	(0.010)
Consumes some production	0.53	0.28	0.49	0.24	-0.62	-1.00*
	(0.330)	(0.370)	(0.330)	(0.370)	(0.540)	(0.560)
Panel C: TOT estimates (self-reported adoption)						
Adopted	1.35**	1.12**	6.62***	7.37***	-0.70	-1.20
	(0.530)	(0.490)	(2.020)	(1.970)	(0.740)	(0.800)
Adopted ×			-0.11***	-0.13***		
Age at baseline			(0.040)	(0.040)		
Adopted ×					3.00***	3.40***
Consumes some production					(0.970)	(1.020)
Age at baseline	-0.01	-0.01	0.03*	0.04**	-0.01	-0.01
	(0.010)	(0.010)	(0.020)	(0.020)	(0.010)	(0.010)
Consumes some production	0.49	0.28	0.38	0.14	-1.01	-1.40**
	(0.330)	(0.370)	(0.360)	(0.400)	(0.630)	(0.650)
Baseline controls	N	Y	N	Y	N	Y
N	370	370	370	370	370	370
Control mean	1.583	1.583	1.583	1.583	1.583	1.583

This table shows results of regressions where the outcome variable is the inverse hyperbolic sine transformation of groundnut output (in kgs) sold to the cooperative.. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Panel C presents 2SLS results where adoption (as reported in the endline survey) is instrumented by treatment status. Columns (3) and (4) additionally include an interaction with the reported age of the baseline respondent, and columns (5) and (6) include an interaction with a dummy equal to one if the farmer reported at baseline keeping any groundnut production for home consumption. In panels B and C, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. Baseline controls included are all variables shown above in Table 1

Table B.7: Sold any output to coop, with behavioral heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: ITT estimates								
Treated	0.13**	0.10**	-0.05	-0.06	0.00	-0.05	0.16***	0.13**
	(0.050)	(0.050)	(0.080)	(0.090)	(0.090)	(0.090)	(0.060)	(0.060)
Treated × Reciprocal			0.38**	0.35*				
			(0.160)	(0.180)				
Treated × Patient					0.16*	0.19*		
					(0.100)	(0.100)		
Treated × Risk loving							-0.15	-0.15
							(0.110)	(0.110)
Reciprocal	-0.05	0.01	-0.28**	-0.20	-0.05	0.01	-0.05	0.00
	(0.110)	(0.120)	(0.110)	(0.120)	(0.110)	(0.120)	(0.110)	(0.120)
Patient	-0.01	-0.04	-0.01	-0.04	-0.09	-0.13	0.00	-0.04
	(0.050)	(0.060)	(0.050)	(0.060)	(0.070)	(0.080)	(0.050)	(0.050)
Risk loving	0.07	0.06	0.07	0.06	0.06	0.06	0.15**	0.15*
	(0.050)	(0.060)	(0.050)	(0.060)	(0.050)	(0.060)	(0.070)	(0.080)
Panel B: TOT estimates (admin data adoption)								
Adopted	0.16***	0.13**	-0.04	-0.06	-0.01	-0.07	0.20***	0.16**
	(0.060)	(0.050)	(0.100)	(0.110)	(0.110)	(0.110)	(0.060)	(0.060)
Adopted × Reciprocal			0.41**	0.38*				
			(0.190)	(0.200)				
Adopted × Patient					0.21*	0.24**		
					(0.120)	(0.120)		
Adopted × Risk loving							-0.19	-0.19
							(0.150)	(0.140)
Reciprocal	-0.07	-0.01	-0.32**	-0.23*	-0.07	0.00	-0.06	0.00
	(0.100)	(0.110)	(0.120)	(0.130)	(0.100)	(0.110)	(0.100)	(0.110)
Patient	0.00	-0.03	0.00	-0.03	-0.11	-0.16*	0.00	-0.04
	(0.050)	(0.050)	(0.050)	(0.050)	(0.080)	(0.090)	(0.050)	(0.050)
Risk loving	0.06	0.06	0.06	0.05	0.06	0.06	0.16*	0.16*
	(0.050)	(0.060)	(0.050)	(0.060)	(0.050)	(0.060)	(0.090)	(0.100)
Panel C: TOT estimates (self-reported adoption)								
Adopted	0.21***	0.16**	-0.02	-0.05	-0.02	-0.09	0.25***	0.21***
	(0.080)	(0.070)	(0.130)	(0.140)	(0.150)	(0.150)	(0.080)	(0.080)
Adopted × Reciprocal			0.48**	0.44*				
			(0.210)	(0.230)				
Adopted × Patient					0.28*	0.31*		
					(0.160)	(0.170)		
Adopted × Risk loving							-0.25	-0.25
							(0.200)	(0.190)
Reciprocal	-0.07	-0.01	-0.34**	-0.26*	-0.07	-0.01	-0.04	0.02
	(0.100)	(0.110)	(0.130)	(0.140)	(0.100)	(0.110)	(0.110)	(0.110)
Patient	0.00	-0.03	0.00	-0.03	-0.15	-0.19*	0.00	-0.04
	(0.050)	(0.050)	(0.050)	(0.050)	(0.100)	(0.100)	(0.050)	(0.060)
Risk loving	0.06	0.06	0.05	0.05	0.07	0.06	0.19*	0.19*
	(0.050)	(0.060)	(0.060)	(0.060)	(0.050)	(0.060)	(0.110)	(0.110)
Baseline controls	N	Y	N	Y	N	Y	N	Y
N	370	370	370	370	370	370	370	370
Control mean	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230

This table shows results of regressions where the outcome variable is a dummy equal to one if the farmer reported selling any output to the cooperative. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Panel C presents 2SLS results where adoption (as reported in the endline survey) is instrumented by treatment status. Columns (3) and (4) additionally include an interaction with a continuous measure of reciprocity bounded in [0,1], columns (5) and (6) include an interaction with a dummy equal to one for self-assessed patient farmers, and columns (7) and (8) include an interaction with a dummy equal to one if the farmer identified as extremely willing to take risks. In panels B and C, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. Baseline controls included are all variables shown above in Table 1

Table B.8: Quantity sold to coop, with behavioral heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: ITT estimates								
Treated	0.89**	0.67**	-0.30	-0.37	0.04	-0.29	1.13***	0.90**
	(0.330)	(0.320)	(0.590)	(0.660)	(0.620)	(0.640)	(0.400)	(0.390)
Treated × Reciprocal			2.55**	2.26*				
			(1.140)	(1.270)				
Treated × Patient					1.06	1.20		
					(0.680)	(0.720)		
Treated × Risk averse							-1.07	-1.06
							(0.740)	(0.750)
Reciprocal	-0.31	0.12	-1.84**	-1.24	-0.35	0.09	-0.35	0.06
	(0.750)	(0.840)	(0.770)	(0.850)	(0.760)	(0.850)	(0.740)	(0.840)
Patient	-0.09	-0.32	-0.11	-0.34	-0.63	-0.92*	-0.05	-0.30
	(0.340)	(0.390)	(0.340)	(0.380)	(0.510)	(0.550)	(0.330)	(0.370)
Risk averse	0.47	0.44	0.48	0.44	0.44	0.40	1.05**	1.03*
	(0.390)	(0.410)	(0.380)	(0.410)	(0.390)	(0.420)	(0.480)	(0.560)
Panel B: TOT estimates (admin data adoption)								
Adopted	1.12***	0.85**	-0.18	-0.31	0.02	-0.43	1.37***	1.11**
	(0.390)	(0.370)	(0.730)	(0.790)	(0.790)	(0.810)	(0.440)	(0.440)
Adopted × Reciprocal			2.70**	2.42*				
			(1.300)	(1.410)				
Adopted × Patient					1.36	1.57*		
					(0.850)	(0.880)		
Adopted × Risk averse							-1.30	-1.33
							(1.010)	(0.980)
Reciprocal	-0.45	-0.01	-2.08**	-1.46	-0.48	0.02	-0.41	0.03
	(0.720)	(0.780)	(0.840)	(0.890)	(0.720)	(0.780)	(0.720)	(0.780)
Patient	-0.03	-0.28	-0.05	-0.29	-0.77	-1.10*	-0.05	-0.31
	(0.330)	(0.360)	(0.320)	(0.350)	(0.580)	(0.610)	(0.330)	(0.360)
Risk averse	0.41	0.39	0.39	0.36	0.43	0.40	1.13*	1.14*
	(0.390)	(0.400)	(0.390)	(0.400)	(0.390)	(0.400)	(0.590)	(0.650)
Panel C: TOT estimates (self-reported adoption)								
Adopted	1.48***	1.12**	-0.07	-0.28	-0.01	-0.54	1.78***	1.42**
	(0.540)	(0.490)	(0.900)	(0.960)	(1.040)	(1.090)	(0.590)	(0.560)
Adopted × Reciprocal			3.18**	2.86*				
			(1.480)	(1.620)				
Adopted × Patient					1.84	2.02*		
					(1.120)	(1.180)		
Adopted × Risk averse							-1.74	-1.79
							(1.390)	(1.320)
Reciprocal	-0.45	-0.05	-2.23**	-1.64*	-0.48	-0.03	-0.28	0.18
	(0.700)	(0.760)	(0.900)	(0.950)	(0.710)	(0.770)	(0.730)	(0.790)
Patient	-0.01	-0.27	-0.03	-0.29	-0.98	-1.31*	-0.06	-0.32
	(0.340)	(0.370)	(0.340)	(0.360)	(0.690)	(0.730)	(0.340)	(0.380)
Risk averse	0.44	0.40	0.36	0.32	0.48	0.44	1.34*	1.33*
	(0.390)	(0.410)	(0.390)	(0.410)	(0.390)	(0.400)	(0.730)	(0.770)
Baseline controls	N	Y	N	Y	N	Y	N	Y
N	370	370	370	370	370	370	370	370
Control mean	1.583	1.583	1.583	1.583	1.583	1.583	1.583	1.583

This table shows results of regressions where the outcome variable is the inverse hyperbolic sine transformation of groundnut output (in kgs) sold to the cooperative.. Panel A presents Intention-To-Treat results where the outcome is regressed on treatment status. Panel B presents 2SLS results where adoption (as measured in cooperative administrative data) is instrumented by treatment status. Panel C presents 2SLS results where adoption (as reported in the endline survey) is instrumented by treatment status. Columns (3) and (4) additionally include an interaction with a continuous measure of reciprocity bounded in [0,1], columns (5) and (6) include an interaction with a dummy equal to one for self-assessed patient farmers, and columns (7) and (8) include an interaction with a dummy equal to one if the farmer identified as extremely willing to take risks. In panels B and C, the 2SLS regressions additionally include treatment interacted with the cooperative dummy as a second instrument. Standard errors are clustered at the treatment assignment (village) level. Baseline controls included are all variables shown above in Table 1

C Agro-climatic conditions and aflatoxin contamination

Table C.1: Agro-climatic predictors of aflatoxin contamination

	(1)	(2)	(3)
3-day dry spells	0.70		0.91
	(0.75)		(0.74)
(3-day dry spells)^2	-0.01		-0.01
	(0.01)		(0.01)
Max temperature		-5.96***	-6.68***
		(1.45)	(1.70)
(Max temperature)^2		0.07***	0.08***
		(0.02)	(0.02)
Observations	173	173	173
R^2	0.144	0.173	0.180

Results in this table are from linear regressions of the observed aflatoxin level (log-transformed) among control farmers on agro-climatic variables. 3-day dry spells is the number of 3-day dry spells observed during the growing season. Max temperature is the mean value of the max temperature observed in dekadal observations over the growing season. All regressions include commune fixed effects. Standard errors (in parentheses) are clustered at the village level.

Table C.2: Post-harvest practices at endline

	(1) Dried on ground	(2) Used standard storage
Treated=1	0.00	0.01
	(.)	(0.01)
Northern cooperative	-0.01	-0.02
	(0.01)	(0.02)
Treated=1 × Northern cooperative	0.01	-0.02
	(0.01)	(0.02)
Observations	353	353
R^2	0.031	0.020

Results in this table are from linear regressions of self-reported post-harvest practices at endline on the treatment dummy and the cooperative dummy. Dried on ground is a dummy equal to one if the farmer dried his groundnuts directly on the ground, as opposed to a tarp or concrete pad. Used standard storage is a dummy equal to one if the farmer reported using standard single-layer plastic bags to store harvested groundnuts. All regressions include commune fixed effects. Standard errors (in parentheses) are clustered at the village level.

D Baseline details

D.1 Aflasafe script

The following is the script that was presented to farmers in Wolof, translated to English, at the end of the baseline survey:

Now, we would like to talk about aflatoxin and a new product called Aflasafe. Aflatoxin is produced by a fungus that comes from the soil and grows on groundnuts, maize, and other crops. When crops are not dried well, or not stored in dry conditions, this can cause aflatoxin to increase and spread within your stored crops. Aflatoxin has many negative health effects, especially for pregnant women and young children, and can cause liver cancer when consumed in large amounts over time.

Aflasafe is a new product developed to fight aflatoxin. It is a biological product, not chemical, and uses a non-toxigenic fungus to compete against the toxic fungus which produces aflatoxin on crops. It was originally developed by scientists in America and Nigeria, and customized for use in Senegal. It has been tested here for more than five years, and this year is now launching for sale in the market. If you use Aflasafe correctly, it has been shown to reduce aflatoxin levels in crops by 80-100%. It can also help protect your crops during storage.

Aflasafe is not a substitute for correctly drying and storing your groundnuts. But when used together with these good practices, it can make your groundnuts safer to eat. Buyers and exporters are also interested in buying groundnuts without aflatoxin. Aflasafe is designed to be applied in your field, about 6 weeks after planting, just after the last weeding before the flowering. Aflasafe is distributed as a blue coating on sterilized sorghum seeds which will not grow. To apply Aflasafe, you walk around your fields and broadcast the same way as fertilizer but a small amount of seeds evenly. To treat one hectare of groundnuts, you would need to use 10 kg of Aflasafe. The market price of 10 kgs is 10000 CFA.

Here is a video with more information about Aflasafe: **video link (Wolof)**

In partnership with the cooperative, we are making 10 kgs of Aflasafe available for you to purchase. To purchase the Aflasafe, you would visit the cooperative's magasin to pick it up. The Aflasafe will be available from the magasin before the end of July. You should call to confirm it is available before traveling to pick it up. In addition, we will offer a free service to test your production and certify it if it is low in aflatoxin. We will offer this in your normal collection point with the cooperative.

Treated farmers

We have a coupon here that allows you to receive 10 kgs of Aflasafe this month, and pay 10000 CFA in kind when you bring your groundnuts to the buying center. You do not decide now if you want the Aflasafe, but you will need to decide and pick it up at the magasin before September 1. The cooperative will distribute Aflasafe only to those who bring their coupon to the supply shop at the collection point, so make sure to bring this with you.

In addition, the cooperative will send an animateur to your field to help answer any questions you may have about how to properly apply Aflasafe, including the correct time to apply it. They will also verify for the cooperative that you applied Aflasafe to your field.

If your groundnuts pass the low-aflatoxin test and receive quality certification, the buyers at the center will pay you a guaranteed bonus of 40 CFA/kg over the price the cooperative normally pays. If you treat your field with Aflasafe, it is important that you keep those treated groundnuts separate from any others. If you mix them together with untreated groundnuts, it will affect the results of the aflatoxin test.

Do you plan to accept this contract and pick up your Aflasafe from the cooperative?

Control farmers

We have a coupon here that allows you to purchase 10 kgs of Aflasafe from the cooperative supply shop for 10000 CFA. You do not need to decide now if you want the Aflasafe, but you will need to decide and purchase it at the magasin before September 1. The cooperative will distribute Aflasafe only to those who bring their coupon to the supply shop at the collection point, so make sure to bring this with you.

The cooperative may send an animateur to visit your field to verify if you used Aflasafe.

If your groundnuts pass the low-aflatoxin test and receive quality certification, there may be buyers available who will pay more than the normal cooperative price. If you treat your field with Aflasafe, it is important that you keep those treated groundnuts separate from any others. If you mix them together with untreated groundnuts, it will affect the results of the aflatoxin test.

Do you plan to purchase the Aflasafe from the cooperative?

D.2 Behavioral variable measurement

Reciprocity

We define reciprocity as the mean response to the following three questions, for which the answer options were (Always willing / Sometimes willing / Never willing).

- When someone does me a favor, I am willing to return it
- How willing are you to punish someone who treats you unfairly, even if there may be costs for you?
- How willing are you to punish someone who treats others unfairly, even if there may be costs to you?

Patience

We define patience if a respondent responded “Yes, always” or “Yes, sometimes” to the following question:

- In comparison to others, are you a person who is generally willing to give up something today in order to benefit from that in the future?

Risk

Following Charness and Viceisza (2016), we elicited risk aversion using an 11-point scale:

- Please tell me, in general, how willing or unwilling you are to take risks, using a scale from 0 to 10, where 0 means you are "completely unwilling to take risks" and 10 means you are "very willing to take risks." You can also use any number between 0 and 10 to indicate where you fall on the scale, using 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10

Altruism

We define altruism if a respondent responded "Always willing" or "Sometimes willing" to the following question:

- How do you assess your willingness to share with others without expecting anything in return?

Trust

We define trust if a respondent responded "Yes, always" or "Yes, sometimes" to the following question:

- As long as I am not convinced otherwise, I assume that people have only the best intentions

Additionally, we define an alternative measure of trust more specific to our context. We elicited responses on a five point scale to the following questions:

- How much do you trust the farming advice of animateurs from the cooperative?
- How much do you trust the farming advice of lead farmers from your cooperative?