Can Input Access and Market-based Incentives Reduce Food Loss? The Case of Bean Farmers in Guatemala and Honduras

Luciana Delgado,[1] Eduardo Nakasone,[2] and Maximo Torero[3]

Abstract

Rapid population growth, urbanization, and increasing pressure on the world's available agricultural land all pose challenges to food security. Policies to address them aim to increase agricultural yields and productivity rather than reducing food loss. Research on food loss reduction and its impact on improving food security has been limited, with much of the focus on technical interventions to reduce losses at post-harvest stages. Specifically, studies focus on storage and offer limited evidence on where losses occur in the value chain and how cost-effective the interventions are (Stathers et al., 2020). Building on Delgado et al. (2021 a, b) and FAO (2019), whose findings identified that food loss is not only significant at post-harvest stages but also at the pre-harvest level; this paper tested a market-based incentive intervention that could reduce food loss across the value chain. The intervention provided farmers with information on the attributes of food quality buyers required to pay a market price premium. If those attributes were achieved, then it meant that the intervention could lead to food loss reduction, outperforming traditional reduction policies set out by governments, including the provision of input packages. To test this market-based incentives, a randomized control trial (RCT) was conducted with bean producers in Guatemala and Honduras. The results showed that farmers who received market-oriented incentives had reduced bean losses by 6 percent in Guatemala and by 7 percent in Honduras compared with the control group. The results suggested that it could be more effective for governments to switch policies from simply providing input packages to promoting market-based incentives, and share information on standards and promote standards legislation and price premiums at wholesale markets and for agro-processors.

[1] International Food Policy Research Institute (IFPRI), Luciana.Delgado@cgiar.org

[2] Department of Agricultural, Food, and Resource Economics, College of Agriculture and Natural Resources, Michigan State University, eduardo@msu.edu

[3] Food and Agriculture Organization of the United Nations (FAO), Maximo.ToreroCullen@fao.org

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1. Introduction

Globally, policies addressing food insecurity as a result of rapid population growth, changing dietary habits, and mounting pressure on agricultural land have aimed at increasing agricultural yields and productivity, which tend to be costly and time-consuming. Such policies have yet to focus on reducing food loss, nor have they considered food loss reduction as a tool that can help meet growing food demand. Effective interventions to cut food loss will have three impacts: (1) improvement in food security and nutrition through increased food availability (Sustainable Development Goal [SDG] 2: Zero hunger); (2) improvement in productivity and economic growth, as farmers sell more products in the market (SDG 8: Decent work and economic growth); (3) emissions reductions (SDG 13: Climate action) and improved efficiency in natural resource use, especially the use of water and land (SDG 14: Life below water; SDG 15: Life on land).

Interventions to reduce food loss have not provided sustainable or long-lasting solutions (Leavens et al., 2021). Studies on the topic are limited and focus on tangible technical interventions to reduce losses during storage for durable crops (cereals and legumes) and perishable products (fruits, vegetables, and roots and tubers). Therefore, future studies should consider the entire value chain and its key actors (farmers, traders, wholesalers), with a particular focus on identifying critical loss points (Edwardson, 2018).

Stathers et al. (2020) reviewed 12,786 papers and ended up selecting 334 studies to assess systematically post-harvest loss reduction interventions for 22 crops across 57 countries in sub-Saharan Africa and South Asia from the 1970s to 2019. Storage technology interventions targeting farmers dominated the studies reviewed (79 percent). Maize was the most studied crop (23 percent). Most interventions took place in India (33 percent). The assessment clearly showed a lack of research on training, finance, infrastructure, policy, and market interventions. It highlighted the need for interventions beyond technology or handling storage practices. It was also clear that there is a scarcity of studies showing the cost-effectiveness and impact of the interventions.

Delgado et al. (2021 b, c) and FAO (2019) found that losses are not only important at the post-harvest stages but also at the pre-harvest level and suggested a wide range of possible causes of food loss, such as production practices, socio-economic characteristics of the farmer, access to markets, technology, and climatic conditions.

Research is required on the effectiveness of interventions related to pests and diseases, handling practices, and weather-resistant varieties. In addition, food loss solutions are not linked with the other investments producers need, leading to such investments being abandoned over time (Leavens et al., 2021). For example, farmers can adopt practices to reduce aflatoxins in their maize, but if the market does not reward the improvement in the quality of the maize through a price premium, then farmers will discontinue those practices.

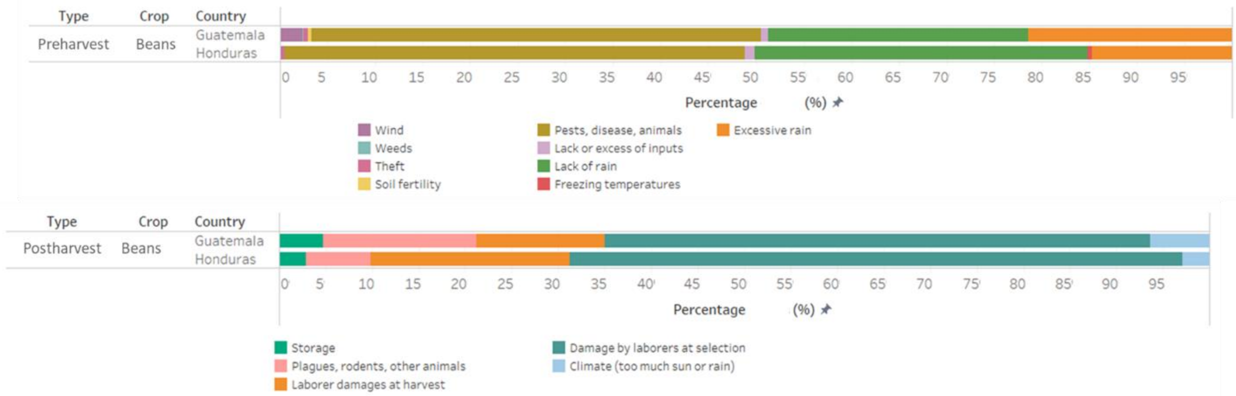
This paper builds on Stathers et al. (2020), Delgado et al. (2021 a, b), and FAO (2019), testing the effectiveness of a market-oriented intervention to reduce food loss across the value chain. The intervention provided farmers with information on the attributes of food quality buyers required to pay a market price premium. If those attributes were achieved, then it meant that the intervention could lead to food loss reduction, outperforming traditional food loss reduction policies set out by governments, including the provision of input packages. To test this, a randomized control trial (RCT) was conducted with bean producers in Guatemala and Honduras.

In Central America, beans are one of the most produced and extensively consumed legumes, and they can serve as a source of income for most populations in rural areas. Globally, post-harvest loss of cereals and legumes can be as high as 9 percent (FAO, 2019). In Guatemala and Honduras, beans are the second most important basic grain produced for consumption.[4] Delgado et al. (2021b; 2021c) found the major causes of loss of beans at the pre-harvest stage in Guatemala and Honduras were pests, lack of rain, and weeds. On the other hand, post-harvest losses were primarily due to damage caused by laborers during selection, as shown in Figure 1. Therefore, the proposed intervention offers an opportunity to address pre- and post-harvest losses that are identified.

The following section describes the design of the intervention. Section 3 presents the data and the empirical approach. Section 4 presents the key findings and is followed by conclusions and policy recommendations. Finally, an appendix with summary statistics is presented.

[4] In Guatemala in 2019, 263,432 metric tons (mt) of beans were produced and an average of 263,659 hectares (ha) was planted, with a yield of 999.1 kilograms per hectare (kg/ha) (FAOSTAT). In Honduras in the same year, bean production was 134,000 mt, and 167,574 ha were planted, with a yield of 802 kg/ha (FAOSTAT).

Figure 1. Self-reported causes of losses



Source: Delgado, Schuster, and Torero (2021b).
Note: This figure shows reported causes of food loss for the entire value chain, comprising the pre- and post-harvest stages, in Guatemala and Honduras.

2. Intervention Design: A Randomized Controlled Trial of a Market-Based Intervention

We tested an innovative approach to reducing food loss across the value chain, which targeted bean producers in Guatemala and Honduras for the *postrera* (second) season in 2017. We followed a contract farming design mechanism based on market incentives, as Saenger et al. (2013). This is referred to as a market-based intervention. The main hypothesis was that if small- and medium-size bean producers know in advance the quality standards required to get a price premium, they will find a way to achieve them using existing technology and by acquiring seeds and fertilizers they need. This would lead to food loss reduction.

In both countries, we conducted an RCT to test the market-based intervention previously described and measure its impact on crop losses and the degree to which farmers complied with quality standards. In Honduras, thanks to the bigger sample size, we were also able to conduct an additional single-arm randomized controlled trial, which evaluated the impact of providing technical assistance and packages of seeds and fertilizers to farmers from the government. In both countries, the control group only received generic information rather than detailed quality standards. Table 1 describes the official quality standards in both countries, which are similar and composed of six dimensions: moisture, impurity, damaged grain, broken grain, presence of live pests, and odor. Non-compliance with any of the dimensions automatically disqualifies the quality of the grain. As a result, the farmer would not receive the price premium for the grain, resulting in losses because of the loss of value of the bean.

Table 1: Quality standards for beans in Guatemala and Honduras

Quality standards	Guatemala (%)	Honduras (%)
Moisture	12–14	14
Impurity	Up to 3	Up to 1
Damaged grain	Up to 8	Up to 3
Broken grain	Up to 5	Up to 2
Presence of live pests	None	None
Odor	Normal	Normal

Source: Authors' elaboration based on technical information collected from the Directorate for Agricultural Science and Technology (DICTA) in Honduras and from ALBAY S.A. in Guatemala.

To measure these six quality standards, three methods were used: organoleptic test, moisture test, and damage measurement test. The organoleptic test measures appearance, odor, presence of live and/or dead insects independently and excreta. For this test, the beans were sifted (screen holes in the sifter are one-eighth of an inch so that only the impurities can pass), and then the proportion of impurities was calculated. After that, the appearance, color, odor, and presence of live pests were analyzed. To measure the moisture in the beans, a portable grain moisture tester "Agratronix MT-16"[5] was used. Finally, to measure damage, characteristics in the grain like heating, presence of fungus, damage by insects, broken, and other damages were assessed. Each type of damage has its characteristics, and the enumerators were trained to identify each of them and weigh the damaged grain.

Intervention design in Guatemala

In Guatemala, we implemented a single-arm RCT. The treatment group was composed of 252 producers who received improved seeds and fertilizers, information on the standards required by the buying company and on the quality-contingent price premium paid by the firm. These are described in Figure 2. The control group was composed of 177 farmers who only received seed and fertilizer packages traditionally provided by the government.

For the treatment group, ALBAY S.A.[6] functioned as a partner for the study by agreeing to provide the required attributes needed to purchase the beans. The company provided the price premium incentive by purchasing the products.

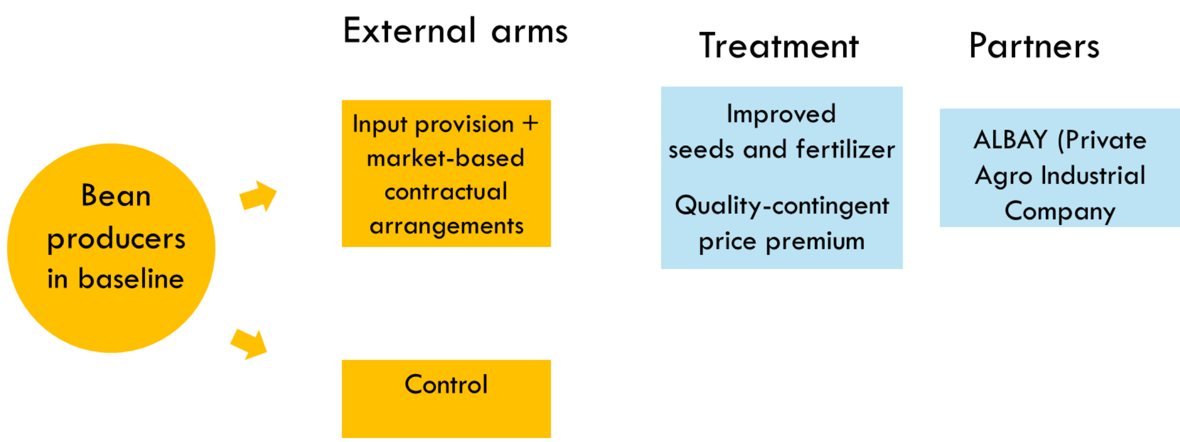
A total of eight training events were carried out in the departments of Sacatepéquez, Chimaltenango, Sololá, Totonicapán, Quetzaltenango, and San Marcos in Guatemala, covering a

[5] See https://www.agratronix.com/shop/grain/mt-16/.

[6] Albay S.A. is a private company based in Guatemala. They are dedicated to producing the best varieties of beans and other grains and products to provide Guatemalan families with adequate food. See http://albay.com.gt.

total of 252 producers. The producers were selected based on their location. They received training on how to achieve the attributes required, as shown in Table 1, with the support of the Institute of Agricultural Science and Technology (ICTA). The training and training material were provided by three agricultural extension officers from different departments. The training took place in community centres, and transportation costs were paid for to ensure the participation of all the producers. The producers selected a delegate for each community, tasked to communicate any problems during production to the agricultural extension officer.

Figure 2. Diagram of the Guatemala intervention



Source: Authors' own elaboration
Note: The treatment group was provided with improved seeds, NPK fertilizer, technical support for input management, and access to a market with a price premium higher than the average retail market in Guatemala City. Total treated producers were 252. The control group was visited after the harvest time to measure the quality of the production they had at that moment. Total control producers were 177.

As in many contractual arrangements, seed and fertilizers were distributed locally to the producers. Specifically, certified seeds of the varieties "ICTA Superchiva"[7] and "ICTA ligero"[8] were distributed at the local level by ALBAY S.A. The total quantity of seeds distributed was 1,751.1 pounds, of which 97 percent was variety "ICTA Superchiva", and 3 percent was "ICTA ligero." The fertilizer was purchased in local agrochemical stores closest to the communities. The total quantity of fertilizer distributed was of 5,368.29 pounds; 90 percent was of the mix 20-20-0 (N-P-K), and the rest was the fertilizer Nitrocomplex of the mix 21-7.5-2.7 (N-P-K). The

[7] "ICTA Superchiva" is a black bean variety with a crop cycle of 120 to 135 days. It's tolerant to argeño (tizon) and moderately tolerant to rust. It yields approximately 20 to 25 quintals per apple and adapts very well to regions of the Guatemalan highlands with altitudes between 1800 and 2400 meters above sea level (ICTA, 2011).
[8] "ICTA ligero" is an early variety with a crop cycle of 71 days to harvest, resistant to the golden mosaic virus and with a yield of 20 to 25 quintals per apple approximately (ICTA, 2015).

ratio of the distribution of seeds and fertilizer for producers was 1:3. Each farmer received three visits by extension officers in addition to the group training.

Finally, the producers agreed to sell the products that meet the quality standards to ALBAY S.A. The company committed to paying a price premium, if quality attributes were met. This price incentive was higher than the average retail market price in Guatemala City.

Intervention design in Honduras

In Honduras, a bigger sample size allowed us to conduct two trials, differentiating the impact of the input package of fertilizers and seeds normally provided by the Government of Honduras (treatment 1) from the impact of a market-based intervention of a quality-contingent price premium (treatment 2). As was the case for Guatemala, extension officers provided treatment 2 group with detailed information on how to achieve those standards. The control group simply received traditional extension services provided by the government. Figure 3 describes the intervention in detail.

Treatment 1 was conducted in 33 villages with 232 producers. The Minister of Agriculture technological package (improved seed and fertilizer) was distributed to all treated producers. Up to 75 pounds of seed and 300 pounds of fertilizer. IHMA will purchase production that reaches a certain quality. Treatment 2 consisted of a price premium when producers achieve certain quality standards. These incentives were complemented with training on how to achieve quality standards and how these standards would be measured. Treatment 2 was implemented in 35 villages, with 209 producers. Under this treatment, all produce to be sold to IHMA and which complies to the agreed attributes will be purchased by IHMA at their official price plus a 10 percent of the price in the Tegucigalpa market as the price premium. Finally, the control group did not receive supplies or bonuses, but the group did receive the traditional extension services provided by the government as did the other producers in the treatment groups. This control group was visited after harvest to measure the quality of the products. The control group comprised 230 producers in 39 villages.

The RCT was conducted in partnership with the Directorate for Agricultural Science and Technology (DICTA),[9] which provided the extension services similar to those of ICTA in Honduras. Another partner was the Honduran Institute of Agricultural Marketing (IHMA),[10]

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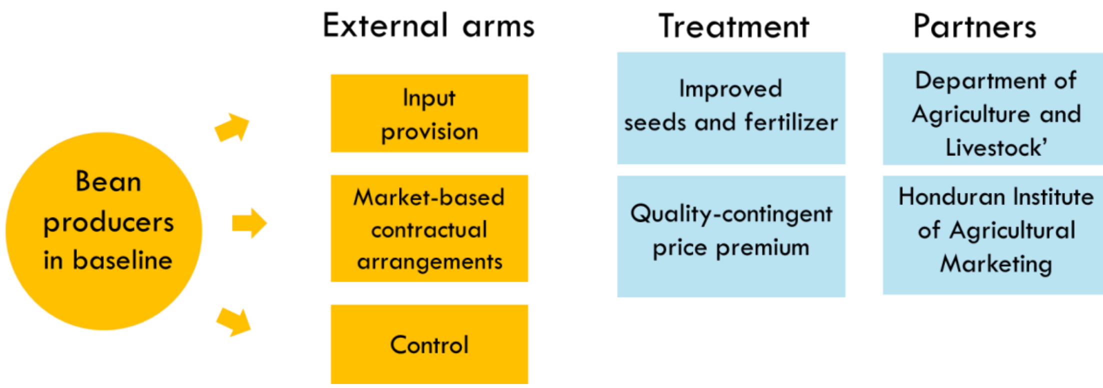
[9] DICTA is an extension agency of the government of Honduras and is a division of the Honduran Department of Agriculture and Livestock. Their objective is to increase agricultural production and productivity through the provision of goods and services and development of technology. This would help meet the food security need of the population, promoting sustainable use of natural resources.

[10] IHMA was created in 1978 as an independent institution. Their goal is the acquisition of basic grains for strategic reserve. They also try to stabilize prices in the national market and purchase grains at competitive market prices. Currently IHMA supplies basic grains to the National Commodity Supplier (BANASUPRO) as as government policy to

providing similar role ALBAY S.A. provided in Honduras, purchasing the beans that met the standards stated in Table 1 and paying the price premium incentive to farmers whose products met the standards.

Figure 3. Diagram of the Honduras intervention



Source: Authors' own elaboration

Note: Two treatments were implemented. Treatment 1 consisted of the_provision of improved inputs. This includes the distribution of improved seeds and fertilizers. The seeds and fertilizers were distributed to the farmers through a government assistance program. This distribution was complemented with input management assistance. Treatment 1 occurs in 33 villages, with 232 producers. SAG technological package (improved seed and fertilizer). Up to 75 pounds of seed and 300 pounds of fertilizer. IHMA will purchase production that reaches a certain quality. Treatment 2 consisted of a price premium when producers achieve certain quality standards. These incentives need to be complemented with training about methods to achieve quality standards (and how these standards would be measured). Treatment 2 was implemented in 35 villages, with 209 producers. Production that reaches a certain quality is purchased at IHMA price + 10 percent of the price in the Tegucigalpa market as the price premium. Finally, the control group did not receive supplies or bonuses. This group was visited after the harvest time to measure the quality of the production they had at that moment. The control group was in 39 villages, with 230 producers.

Treatment 1 received certified seeds and fertilizers and extension services from DICTA. The technological package distributed in each department office by DICTA consisted of certified seed variety "*Amadeus*"[11] and fertilizer 12-24-12 (NPK). We conducted a training in each of the ten departments with DICTA. The training gave an explanation of the treatment and distributed the technological package. In addition, the farmers in each department selected a delegate per community, and this person was in charge of communicating with DICTA any problems that occurred during production. The producers were also informed that if their products met the

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ensure vulnerable populations can purchase food at reasonable prices. The process of buying and selling basic grains is done in accordance with the marketing regulation for agricultural products.

[11] "*Amadeus*" is a red bean variety with a crop cycle of nighty days. It is resistant to the golden mosaic virus and common mosaic virus and moderately tolerant to rust, Anthracnose, common bacterosis, web blight and angular leaf spot. It yields approximately 28 quintals per *manzana*.

IHMA quality standards, they could sell their products to IHMA who would buy them at a higher price.

Treatment 2 producers were also congregated in each department and the treatment was explained in detail. The quality standards required by IHMA was also explained as well as the additional price incentive on top of the IHMA price that they would receive, if they complied with these standards. Treatment 2 farmers were also visited by DICTA extension officers and were provided with technical assistance on what they needed to do to improve their input management and to achieve the bean quality standards. No inputs were distributed to this treatment group.

This RCT allowed us to differentiate between traditional government intervention and a market-oriented incentive in the form of information on standards and a quality-contingent price premium.

3. The Data

Using the baseline survey developed by Delgado et al. (2017; 2021b), we began with a baseline survey that is a representative sample for bean producers for Guatemala and Honduras. These are detailed baseline surveys across the beans value chain. These surveys allowed us to quantify the extent of food loss across the value chain before consumption using the methodology from Delgado et al. (2021b). The surveys also enabled us to characterize the nature of food loss, specifically during which production stages they occurred. In this paper, we focused on the producer survey.

Based on these baseline surveys, we identified a large enough sample size to assure statistical significance of the RCT interventions outcomes in both Guatemala and Honduras. For Guatemala, we randomly selected 450 bean producers from 42 municipalities in eight departments. The treatments were randomly distributed by municipal officers as shown in Figure 4. In Honduras, we randomly selected 685 bean producers from 107 villages in ten departments, and the distribution of the treatments was carried out randomly at the village level, as shown in Figure 5.

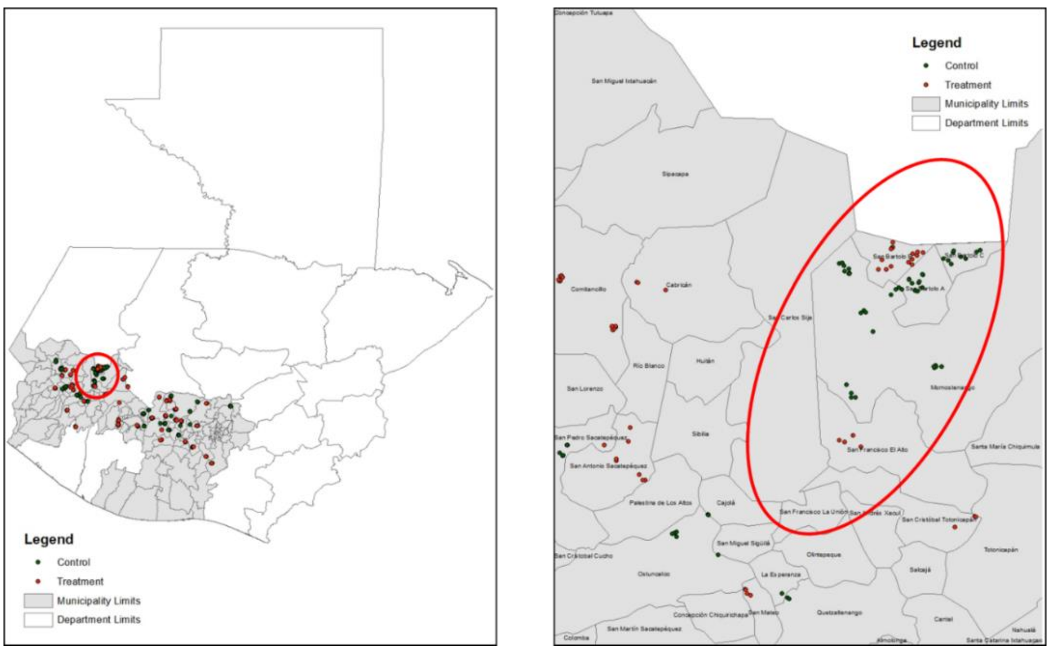
The producer survey had three modules to measure the producers' baseline characteristics and quality attributes of the beans they produce, according to Table 1. The first module asked about the quantity of the beans left in the field, the total production harvested, and the harvest's qualities, attributes, and prices. The second module asked about the quantity that was affected (quality degradation)[12] and the quantity that was totally lost (quantity degradation)[13] during post-harvest activities (e.g., winnowing, threshing, grading, transporting, packaging, etc.). In the

[12] Affected product: Product that lowers quality but can still be used.

[13] Totally lost: Product that is completely lost and cannot be used.

attributes, section producers were asked to evaluate the crops' physical or chemical characteristics. These characteristics are specific to beans and were identified in collaboration with commodity experts, as reported in Table 1. The damage the beans sustained was determined by texture, size, moisture, the presence of fungus or insects to name a few, as detailed in Table 1. Using expert consultations and market research, we confirmed the price punishment each of these types of crop damage entails. The third module recorded the product's destination (e.g., consumption, sale, donation, etc.), as well as the attributes of the beans and the quantity that was destined for sale.

Figure 4. Random assignment of treatment distribution in Guatemala, by municipality



Source: Authors' own elaboration

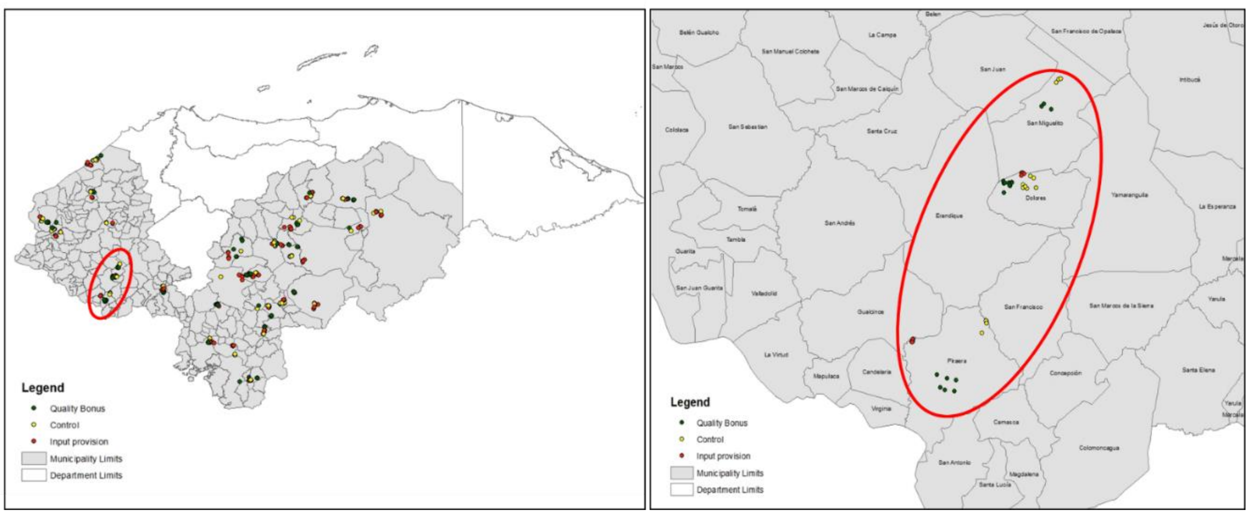
Finally, after the intervention was implemented and the harvest was finished, we measured the quality of beans harvested during the season following the procedure used traditionally by Albay in Guatemala and IHMA in Honduras.

A 6-step procedure was conducted to capture the differences in attributes listed in Table 1. First, the survey taker identified the bean samples for each producer. The beans were stored in sacks at the producer's house in most cases. With a sack sampler or using hands (with gloves), the enumerator took random samples of beans depending on the total quantity of sacks.[14] In each sack, enumerators took the same quantity of beans, and all the samples were put in a bag and mixed to have a homogenized sample. Second, the survey takers took 200 grams of beans

[14] If the producer has less than three sacks, the enumerator took one sample per sack, if the producer has more than three sacks, he will choose three sacks randomly to be sample, and if the producers have more than six sacks, we would add one more sample per each three more sacks randomly).

from the mixed bag. Third, the 200 grams were processed using a metal strainer.[15] A strainer was used to filter and remove small particles and impurities from beans. Oversized impurities were removed manually. Fourth, the impurities that passed the strainer were analyzed to check the presence of live and dead insects and/or excretes. The enumerators took notes of appearance, odor, presence of live and dead insects, and excretions. The impurities were weighted to calculate the percentage of impurities. Fifth, the damaged grain that remained in the strainer was analyzed to report the percentage of beans damaged by a) fungus, b) insects, c) broken grain, d) wrinkled grain, and e) others. Sixth, the beans' moisture was measured using the moisture tester Agratronix MT-16. This six-step procedure allowed us to capture the differences in attributes of Table 1 for both the treatment and control samples in Guatemala and Honduras.

Figure 5. Random assignment of treatment distribution in Honduras, by village



Source: Authors’ own elaboration

Some summary statistics

Table A.1 shows summary statistics of the producers in both countries. Around 90 percent were male. On average, they were 48 years old and had between 22 and 26 years of experience of growing beans. Most producers had primary education, but around 25 percent did not have any level of education.

In Guatemala and Honduras, the producers cultivate on average 0.35 ha and 1.47 ha of land, respectively. Less than 9 percent of the producers in both countries use improved seeds. Machine-driven production methods, such as soil preparation, sowing, pest control, fertilizer

[15] The metal strainer was designed to sample beans with orifices of 1/8 inches.

application, weeding, mulching, cutting, and harvesting were almost non-existent in the bean value chain in both countries.

Mechanization in post-harvest activities is even less common. However, in Honduras, farmers engage in mechanical threshing of beans. Very few farmers in both countries mechanically dry and winnow the beans.

In Guatemala, 89 percent of producers store their beans for six months on average. In Honduras, 99 percent of producers store their beans for 4 months on average. In both countries, the producers store the beans in their houses.

Finally, on average, 35 percent of the beans are sold by farmers, and the sales transaction were mainly at home or at the plot. In Guatemala, most of the production was sold to consumers and a small part to wholesalers. In Honduras, most of the products were sold to intermediaries and a minor part to consumers.

Tables A.2 and A.3 show the producer characteristics by each treatment group in Guatemala and Honduras, respectively.[16]

4. Results

In both Honduras and Guatemala, the interventions reduced food loss. The producers used inputs, technology, and markets already in place. Tables 2 and 3 present the results, and in each table, we include the six dimensions of attributes specified in Table 1. In addition, for each attribute we have three models: (a) the first one does not include any control, (b) the second model includes duplet and triplet controls for Guatemala and Honduras respectively, and (c) the third model includes both the duplet and triplet controls as well as a control for the enumerator. For all attributes and models, the coefficient for the treatment effect is included as well as its standard errors and significance level. Specifically, for Guatemala we only have one treatment as previously explained and for Honduras two treatments.

In Guatemala, the treatment that consisted of a combination of information, seeds, and fertilizer packages had an impact. The effect was especially noticeable with grains that sustained insect damage and wrinkle grain. For the former, around 5 percent reduction in losses was observed compared with the control. For the wrinkle grain, around 2 percent of loss reduction was observed compared to the control group, as shown in Table 2.

In Honduras, we observed that the treatment consisting of market incentives to farmers relative to government incentives had a significant effect. This was especially noticeable in terms of reduced dirt and impurities—an improvement that farmers could achieve by

[16] These characteristics were collected in a previous survey that measures losses as a baseline (see Delgado et al., 2017, 2021). We worked with the same producers for this paper.

themselves. Here, a 7 percent reduction in losses was observed compared with the control group as shown in Table 3. Without any government intervention, farmers were thus able to increase the share of their production that garnered the premium price.

Table 2: Impact on attributes of intervention in Guatemala

	Dirt/ impurities			Broken grain			Fungal damage		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treatment	0.217	0.345	0.364	-0.019	0.032	0.045	-0.234	-0.195	-0.175
	(0.425)	(0.406)	(0.399)	(0.1)	(0.083)	(0.082)	(0.276)	(0.21)	(0.214)
N. of obs.	314	314	314	314	314	314	314	314	314
Control mean	1.257	1.257	1.257	0.305	0.305	0.305	0.776	0.776	0.776
Duplet controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Enumerator controls	No	No	Yes	No	No	Yes	No	No	Yes

	Insect Damage			Wrinkled grain			Other damage		
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Treatment	-0.849	-0.518*	-0.485*	-0.183	-0.212*	-0.199*	0.014	0.071	0.095
	(0.549)	(0.26)	(0.261)	(0.175)	(0.114)	(0.113)	(0.207)	(0.178)	(0.185)
N. of obs.	314	314	314	314	314	314	314	314	314
Control mean	1.544	1.544	1.544	0.662	0.662	0.662	0.771	0.771	0.771
Duplet controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Enumerator controls	No	No	Yes	No	No	Yes	No	No	Yes

Source: Authors' own calculations

Note: *** statistically significant at 0.001, ** statistically significant at 0.01, and * statistically significant at 0.05

Table 3: Results for Honduras Impact in attributes of intervention in Honduras

	Dirt/ impurities			Broken grain			Fungal damage		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treatment 1	-0.079	-0.117	-0.116	-0.002	-0.023	-0.019	-0.063	-0.034	-0.028
	(0.244)	(0.301)	(0.317)	(0.032)	(0.031)	(0.029)	(0.214)	(0.24)	(0.248)
Treatment 2	-0.629*	-0.554*	-0.479*	0.043	0.057	0.058	0.233	0.236	0.267
	(0.335)	(0.314)	(0.268)	(0.045)	(0.043)	(0.041)	(0.374)	(0.391)	(0.394)
N. of obs.	515	515	515	515	515	515	515	515	515
Control mean	1.69	1.69	1.69	0.121	0.121	0.121	0.904	0.904	0.904
Triplet controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Enumerator controls	No	No	Yes	No	No	Yes	No	No	Yes

	Insect Damage			Wrinkled grain			Other damage		
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Treatment 1	-0.045	-0.029	-0.042	0.016	0.28	0.258	0.268	0.494	0.477
	(0.181)	(0.234)	(0.247)	(0.312)	(0.381)	(0.371)	(0.196)	(0.328)	(0.343)
Treatment 2	0.01	0.037	-0.019	0.525	0.574	0.525	0.763	0.804	0.755
	(0.263)	(0.255)	(0.244)	(0.481)	(0.487)	(0.496)	(0.543)	(0.577)	(0.587)
N. of obs.	515	515	515	515	515	515	515	515	515
Control mean	0.816	0.816	0.816	3.037	3.037	3.037	1.653	1.653	1.653
Triplet controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Enumerator controls	No	No	Yes	No	No	Yes	No	No	Yes

Source: Authors own calculations

Note: *** statistically significant at 0.001, ** statistically significant at 0.01, and * statistically significant at 0.05

These results are important as they show that farmers will be motivated to produce more and better beans, if they are given information on quality standards and price premiums for higher quality beans. The results from Guatemala showed that merely *possessing information* about quality-contingent price premiums was enough to prompt farmers to comply with those standards. This, in turn, led to improvements in food quality, reduced losses and led to increased payment of premium prices to farmers.

5. Conclusions

The market-based incentives treatment seems to perform better than traditional, subsidized packages of fertilizer and seeds. This could mean that farmers with proper incentives and full information on quality standards demanded by markets can reduce losses better than those farmers who only received technological packages.

It is therefore important to design interventions that are based on market incentives. For the greatest impact, farmers must be linked to buyers through contract farming or through horizontal coordination arrangements, such as farmer associations or cooperatives. Our results also show that governments could play an important role by setting market standards and recognizing produce quality. Simply providing detailed information on the quality standards required by private companies could spur markets to reward quality improvements through price premiums. Such interventions will incentivize farmers to reduce their quality losses and increase their revenues, which would make it possible for them to increase investment in the quality of their inputs and time to properly manage the beans in their future planting seasons.

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Appendix

Table A.1: Producer Characteristics

Variable name			Guatemala: beans		Honduras: beans	
			mean	std dev	mean	std dev
Socio-economic characteristics	Gender (male)		88%	0.33	95%	0.22
	Age (years)		48.75	15.03	47.78	14.47
	Education	no education	29%	0.45	17%	0.38
		primary	65%	0.48	79%	0.40
		secondary	4%	0.19	2%	0.16
		>secondary	2%	0.14	1%	0.09
	Household size		6.11	2.62	5.03	2.12
	Experience in cultivating crop		22.53	15.17	26.37	15.16
Market access	Cost to reach market (USD/ Kg)		1.38	1.11	0.02	0.03
	Time to reach market (hours)		1.38	1.11	3.28	3.34
Production	Quantity produced last harvest		145	256	629	1,171
	Area cultivated (in hectares)		0.35	0.76	1.09	1.47
	Improved seeds (dummy)		4%	0.19	9%	0.29
	Time of planting: primera vs postrera		75%	0.43	33%	0.47
	Number of different inputs applied[a]		1.72	1.05	2.72	1.20
	Number of different field maintenance activities[b]		0.04	0.20	0.10	0.30
	Number of mechanic production activities[c]		0.05	0.39	0.32	0.78
	Hired labor (dummy)		37%	0.48	94%	0.24
Post-harvest[f]	Nb of post-harvest activities[d]		3.88	0.66	3.69	0.83
	Mechanical drying and		2%	0.13	4%	0.19
	Mechanical transport		16%	0.36	23%	0.42
	Storage (dummy)		99%	0.10	89%	0.31
	Storage time (in days)		187	105	146	85
	Storage location	Silo	3%	0.17	10%	0.30
		Granary/ Barn	1%	0.12	4%	0.20
		House (bag)	96%	0.21	85%	0.35
	Number of storage conservation activities[e]		0.41	0.57	0.68	0.47
Sales	Percentage sold (versus own consumption, barter, animals or seeds)		31%	0.25	40%	0.32
	Sale location[g]	house or plot	63%	0.48	86%	0.35
		nearest town	26%	0.44	2%	0.14
		village market	6%	0.24	12%	0.33
	Type of buyer the farmers sells	middlemen	5%	0.22	55%	0.50
		wholesaler	21%	0.41	17%	0.38
		processor	1%	0.09	0%	
		consumer	67%	0.47	31%	0.46
	Number of transactions to sell		1.97	3.30	1.26	1.28

Note: a) This includes fertilizers, insecticides, herbicides, and fungicides; b) This includes activities such as irrigation, trimming, and pruning; c) Machine-driven, instead of manual, include activities such as soil preparation, sowing, pest control, fertilizer application, weeding, mulching, cutting and harvest; d) This includes activities such as selection, classification, drying, etc. e) This includes activities such as chemical fumigation, natural fumigation, and ventilation; f storage summary statistics are obtained from the restricted sample of farmers storing grains; g) These variables are not mutually exclusive, as farmers can

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g These variables are not mutually exclusive, as farmers can have more than one sales' location and type of buyer

Table A.2: Producer characteristics- Guatemala beans

Variable name			Control		Input provision+Market-based contractual arrangements		
			178		252		
			mean	std dev	mean	std dev	t-test
Socio-economic characteristics	Gender (male)		88%	0.33	88%	0.329	n.s.
	Age (years)		49.376	15.313	48.056	14.961	n.s.
	Education	no education	29%	0.453	29%	0.456	n.s.
		primary	67%	0.472	64%	0.48	n.s.
		secondary	4%	0.195	4%	0.196	n.s.
		>secondary	1%	0.075	2%	0.153	n.s.
	Household size		6.19	2.713	6.04	2.553	n.s.
	Experience in cultivating crop (years)		22.92	15.694	22.36	14.821	n.s.
Market access	Cost to reach market (USD/ Kg)		1.42	1.302	1.38	0.972	n.s.
	Time to reach market (hours)		1.43	1.303	1.37	0.972	n.s.
Production	Quantity produced last harvest (Kg)		140.2	301.232	125.8	158.84	n.s.
	Area cultivated (in hectares)		0.42	1.045	0.28	0.418	*
	Improved seeds (dummy)		3%	0.181	3%	0.176	n.s.
	Time of planting: primera vs postrera		78%	0.415	71%	0.453	n.s.
	Number of different inputs applied[a]		1.70	1.123	1.71	0.993	n.s.
	Number of different field maintenance activities[b]		0.07	0.251	0.02	0.153	**
	Number of mechanic production activities[c]		0.02	0.129	0.07	0.492	n.s.
	Hired labor (dummy)		33%	0.472	41%	0.492	n.s.
Post-harvest[f]	Nb of post-harvest activities[d]		3.93	0.664	3.87	0.658	n.s.
	Mechanical drying and winnowing		2%	0.129	2%	0.125	n.s.
	Mechanical transport		16%	0.365	16%	0.37	n.s.
	Storage (dummy)		99%	0.106	99%	0.089	n.s.
	Storage time (in days)		182	111.555	193	99.531	n.s.
	Storage location	Silo	6%	0.231	2%	0.125	**
		Granary/ Barn	1%	0.106	2%	0.125	n.s.
		House (bag)	92%	0.27	97%	0.18	*
	Number of storage conservation activities[e]		0.36	0.557	0.428	0.556	n.s.
Sales	Percentage sold (versus own consumption, barter, animals or seeds)		31%	0.257	32%	0.254	n.s.
	Sale location[g]	house or plot	59%	0.493	66%	0.475	n.s.
		nearest town	27%	0.445	26%	0.438	n.s.
		village market	9%	0.287	4%	0.196	**
		middlemen	6%	0.241	4%	0.196	n.s.
	Type of buyer the farmers sells to[g]	wholesaler	22%	0.415	22%	0.414	n.s.
		processor	1%	0.075	1%	0.109	n.s.
		consumer	61%	0.49	69%	0.462	*
	Number of transactions to sell last harvest		1.88	3.66	2.04	3.024	n.s.
	Total area cultivated last season - in manzanas; all crops; own and not own lan		0.949	1.568	0.83	1.836	n.s.
	beans area cultivated last season - in manzanas; own and not own land		0.593	1.481	0.393	0.593	*
	Travel time to market pop 20k+ from cabecera		0.47	0.864	0.292	0.611	**
	Travel time to market pop 50k+ from cabecera		0.628	0.901	0.507	0.612	*
	Travel time to listed market from cabecera		1.164	1.017	0.971	0.743	**
	Travel time to market pop 20k+ from Mun centroid		1.105	0.805	1.284	1.029	*
	Travel time to market pop 50k+ from Mun centroid		1.295	0.855	1.48	0.964	**
	Travel time to listed market from Mun centroid		1.758	0.981	1.923	1.124	n.s.
	Municipality Poverty Rate		65.376	15.677	65.602	19.7	n.s.
	Municipality Population		27875.92	25811.10	31239.1	27223.20	n.s.
	Fertility index (1-4)		2.626	0.492	2.562	0.406	n.s.
	Land physical characteristics Index (1-5)		4.432	0.756	4.325	0.631	n.s.
	Organic Matter Content Index (1-6)		4.258	0.938	4.084	0.951	*

Note: *** p<0.01, ** p<0.05, * p<0.1. a) This includes fertilizers, insecticides, herbicides and fungicides; b) This includes irrigation and "chapeo"; c) Machine-driven production activities include cleaning, sowing, herbicide application, pest control, fertilizer application, and harvest; d) This refers to winnowing (sopla), threshing (desgrane), drying, putting in bags, and transport; e) This includes chemical fumigation, natural fumigation, and ventilation; f) storage summary statistics are obtained from the restricted sample of farmers storing the grains; g) These variables are not mutually exclusive, as farmers can have more than one sales' location and type of buyer

Table A.3: Producer characteristics- Honduras beans

Variable name			Control		Market-based contractual arrangement			Input provision		
			230		210			232		
			mean	std dev	mean	std dev	ttest	mean	std dev	ttest
Socio-economic characteristics	Gender (male)		94%	0.25	95%	0.21	n.s	96%	0.19	n.s
	Age (years)		47.22	14.85	48.11	14.14	n.s	48.27	14.42	n.s
	Education	no education	13.5%	0.34	21.4%	0.41	n.s	17.2%	0.38	n.s
		primary	83.9%	0.37	75.7%	0.43	**	78.0%	0.42	n.s
		secondary	1.7%	0.13	1.9%	0.14	**	3.9%	0.19	n.s
		>secondary	0.9%	0.09	1.0%	0.10	n.s	0.9%	0.09	n.s
	Household size		5.05	2.23	5.14	2.07	n.s	4.97	2.09	n.s
	Experience in cultivating crop (years)		26.44	15.45	26.30	14.61	n.s	26.82	15.44	n.s
Market access	Cost to reach market (USD/ Kg)		0.02	0.03	0.03	0.04	***	0.02	0.03	n.s
	Time to reach market (hours)		3.00	2.92	4.02	3.61	***	2.94	3.43	n.s
Production	Quantity produced last harvest (Kg)		31720.48	61765.86	27620.29	54359.14	n.s	27435.4	43558.13	n.s
	Area cultivated (in hectares)		1.15	1.70	0.98	1.07	n.s	1.17	1.57	n.s
	Improved seeds (dummy)		13%	0.33	7%	0.25	**	7%	0.26	*
	Time of planting: primera vs postrera		31%	0.47	41%	0.49	**	28%	0.45	n.s
	Number of different inputs applied[a]		2.6	1.21	2.762	1.27	n.s	2.81	1.12	n.s
	Number of different field maintenance activities[b]		0.09	0.28	0.095	0.29	n.s	0.10	0.31	*
	Number of mechanic production activities[c]		0.27	0.77	0.29	0.68	n.s	0.37	0.80	n.s
	Hired labor (dummy)		96%	0.19	93%	0.25	n.s	95%	0.22	n.s
Post-harvest[f]	Nb of post-harvest activities[d]		3.74	0.86	3.68	0.75	n.s	3.68	0.84	n.s
	Mechanical drying and winnowing		4%	0.18	2%	0.15	n.s	5%	0.22	n.s
	Mechanical transport		21%	0.41	23%	0.42	n.s	24%	0.43	n.s
	Storage (dummy)		90%	0.31	86%	0.35	n.s	92%	0.27	n.s
	Storage time (in days)		148	86.86	147	83.85	n.s	148	82.90	n.s
	Storage location	Silo	10%	0.30	11%	0.31	n.s	9%	0.29	n.s
		Granary/ Barn	5%	0.21	4%	0.21	n.s	3%	0.17	n.s
		House (bag)	76%	0.43	84%	0.37	n.s	87%	0.33	n.s
	Number of storage conservation activities[e]		0.64	0.49	0.65	0.48	n.s	0.69	0.46	n.s
Sales	Percentage sold (versus own consumption, barter, animals or seeds)		40%	0.33	38%	0.31	n.s	41%	0.33	n.s
	Sale location[g]	house or plot	89%	0.32	88%	0.33	n.s	82%	0.39	n.s
		nearest town	2%	0.15	2%	0.14	n.s	2%	0.13	n.s
		village market	9%	0.29	10%	0.31	n.s	18%	0.38	n.s
	Type of buyer the farmers sells to[g]	middlemen	54%	0.50	58%	0.50	n.s	55%	0.50	n.s
		wholesaler	14%	0.35	18%	0.38	n.s	20%	0.40	**
		processor	0%	0.00	0%	0.00	n.s	0%	0.00	n.s
		consumer	33%	0.47	28%	0.45	n.s	28%	0.45	n.s
	Number of transactions to sell last harvest		1.32	1.58	1.26	1.31	n.s	1.19	0.84	*

Note: *** p<0.01, ** p<0.05, * p<0.1. a) This includes fertilizers, insecticides, herbicides and fungicides; b) This includes irrigation and "chapeo"; c) Machine-driven production activities include cleaning, sowing, herbicide application, pest control, fertilizer application, and harvest; d) This refers to winnowing (sopla), threshing (desgrane), drying, putting in bags, and transport; e) This includes chemical fumigation, natural fumigation, and ventilation; f) storage summary statistics are obtained from the restricted sample of farmers storing the grains; g) These variables are not mutually exclusive, as farmers can have more than one sales' location and type of buyer