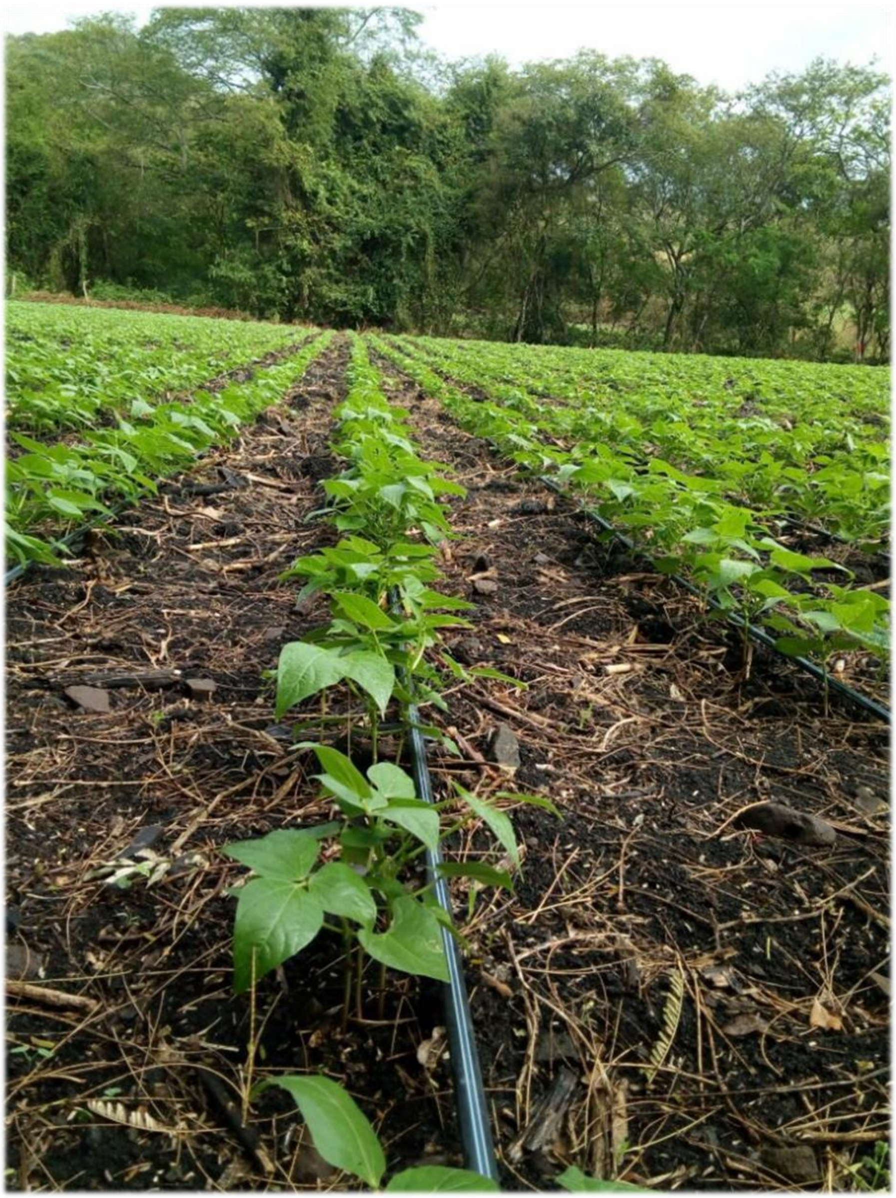
Bean production systems in Nicaragua: technology adoption in the face of climate adversity



BYRON REYES*,
LINA IBARRA,
RICARDO LABARTA
AND
LORENA GÓMEZ

November 2021

---

*Corresponding author (b.reyes@cgiar.org)

Any opinions and errors are solely of the authors and do not necessarily reflect the Alliance's point of view.

Summary

Beans are an important staple in the diets of Nicaraguans, and an important source of income and food security. We documented the bean production systems in Nicaragua, focusing on the adoption of improved bean varieties (IVs) under adverse climatic (rainfall) conditions and its economic effect on adopting households. For this, we identified a representative sample of 589 farmers (341 located in the dry corridor), and using a structured questionnaire, carried out face-to-face interviews between November 27 and December 18, 2017.

The results demonstrate statistical differences in the socioeconomic characteristics, farm characteristics, and bean management practices between IV adopters and non-adopters and by region (i.e., dry vs. non-dry corridors). IV adopters had completed more years of formal education, more participated in farmer groups, had more bean experience, implemented more land conservation practices, received more technical assistance, had better access to household services, planted more land to beans, spent more on bean inputs, and were less food insecure than non-adopting farmers. Similarly, farmers in the dry corridor had more bean experience, fewer economically-dependent family members, implemented more land conservation practices, had better access to household services, more productive assets, owned less land but dedicated more land to beans, spent more on bean inputs, and faced less rainfall than farmers in non-dry regions.

Regarding yields, farmers in the dry corridor obtained significantly lower yields compared to farmers in non-dry areas. Further, 30% of farmers in Nicaragua had adopted at least one improved bean variety in the seasons of interest (August 2016-July 2017), and 28.3% of the bean area was grown with IVs. Adopting an IV positively affected yields --farmers obtained 11% higher yields-- but had no statistically significant effect on profits.

Farmers reported growing more than fifty varieties, but only ten occupied a large part of the total planted area. The most commonly grown variety (regardless of whether it was improved or not) was INTA Rojo. Other commonly grown IVs were INTA Sequía and, to a lesser extent, INTA Norte.

Finally, the results highlight the importance of growing improved bean varieties under adverse rainfall conditions, as farmers who adopted an IV in the dry corridor obtained 13.2% higher yields than non-adopters in the same region. We did not find statistical yield differences between IV adopters and non-adopters in non-dry regions.

Key words: Common Beans, Adoption Rate, Nicaragua, Technology Adoption, Dry Corridor

Table of Contents

List of Tables

List of Figures

1 Motivation

Beans in Nicaragua, along with corn, sorghum, and rice, are considered basic grains and represent an important part of the Nicaraguan diet. Common bean (*Phaseolus vulgaris* L.) is one of the main crops due to its importance at the nutritional, economic, and social levels. According to the Nicaraguan Institute for Agricultural Technology (INTA)[1], this legume is a rich source of protein, calcium, potassium, phosphorus and is low in sodium. IICA (2013) estimates that the per capita consumption is approximately 23 kg per year and is one of the highest in Central America. Reyes (2007) adds that 20% of the calories and 31.1% of the daily protein consumed by Nicaraguans come from beans. Some of the new improved varieties in the country contain more iron than other varieties, a mineral that, when lacking, affects the functioning of the body and is the biggest cause of anemia (HarvestPlus, 2019)[2]. According to the World Health Organization data (WHO, 2017), 16.3% of women of reproductive age and 29.2% of children under five years of age in Nicaragua suffered from anemia in 2016. Beans, including biofortified (i.e., iron-rich) varieties, could significantly contribute to ensuring food and nutrition safety, mostly because they are heavily consumed, especially in the poorest households.

Beans are grown throughout the country. The main producing departments are Matagalpa (17.5% of the bean area), Jinotega (17.4%), Región Autónoma de la Costa Caribe Norte (RACCN, 13.1%), Nueva Segovia (11.5%), and Región Autónoma de la Costa Caribe Sur (RACCS, 7.8%), producing a combined 67.3% of the national annual output (INIDE and MAGFOR, 2012). According to the IV National Agricultural Census (INIDE and MAGFOR, 2012), beans occupy 35.2% of the total land planted with basic grains, representing a little more than two hundred and twenty thousand hectares (224,678 ha) and 50% of the agricultural holdings where beans are planted were less than 7 hectares. During the 2016/2017 agricultural cycle, beans represented 20% of the total production of basic grains in the country (BCN, 2017). In this study, we followed the Food and Agriculture Organization of the United Nations (Van der Zee Arias, Van der Zee, Meyrat, Poveda and Picado, 2012) determination of departments in the dry corridor, which includes 14 of the 17 departments in this region. Following this and using the IV CENAGRO data, we observe that the 14 departments in the dry corridor account for 73.9% of the total area planted with beans.

Regarding trade, Nicaragua is the main producer and exporter of beans from Central America, according to FAOSTAT[3] data. In 2016, bean exports were 55,937 tonnes, generating revenues of USD $56 million, occupying a first place among Central American countries in terms of the volume exported.[4] On the other hand, imports in 2016 closed with 816 tonnes worth USD $718,000, making it a net exporter.

Despite the economic importance of beans, their production is characterized by having one of the lowest yields in Central America. Following FAOSTAT data, the average yield in Nicaragua in the 2016-2017 agricultural year was 0.8 tons per hectare, compared to 0.97 ton/ha in Guatemala, 0.94 ton/ha in El Salvador, and 0.81 ton/ha in Honduras. These data, combined with the trade data, suggest that there may be a high potential for profits if productivity is increased; because farmers could obtain higher volumes in

[1] Online available at: http://www.inta.gob.ni/2019/02/14/evaluacion-sensorial-de-cuatro-variedades-de-frijol-en-siete-municipios-de-los-departamentos-de-matagalpa-y-jinotega/

[2] Online available at: https://www.harvestplus.org/what-we-do/nutrition

[3] Available at: http://www.fao.org/faostat/en/#data/TP

[4] Includes all bean-producing countries, regardless of the market class.

the same (or less) area, generating profits not only to farming households but also the environment and consumers in general.

There are many alternatives for farmers to obtain higher yields, including using purchased inputs, adequately managing pests and diseases during the crop cycle, using improved varieties and high-quality seed, among other crop management options. Improved varieties are currently developed through genetic improvement driven by different needs, such as adverse weather conditions, diseases, yields, nutritional content, and others (Araya, Rodríguez, Molina, & Ramos, 1992). With support from different organizations, INTA has released 21 improved varieties until 2019, five of which are biofortified (iron-rich) varieties[5], in an effort to improve the quality of beans and their productivity. The use of these varieties provides potential advantages to adopters, for example, in terms of resistance to specific diseases, which translates into an increase in productivity (Araya et al. 1992), potentially allowing farmers not only to become food secure but also to generate household income from marketing production surplus. Under controlled environments (i.e., experimental stations), these new varieties have shown high yield potential (of over 2 ton/ha in some cases). Although these yields are usually not expected under farmer conditions, the yield gap is too wide. Although recent studies have reported levels of adoption of improved bean varieties in Nicaragua of 82% (Reyes *et al*., 2016), we suspect that adoption rates may be lower because (a) these estimations were not made using representative farm-level data, and (b) the national average yields are quite low.

This study contributes to closing this informational gap by using representative farm-level data to estimate adoption levels in Nicaragua and study how this decision is affected when cultivating beans under adverse weather conditions (i.e., in the dry corridor). Thus, the main objectives are to (i) provide a description of the main bean production systems in the country and (ii) estimate the adoption rates of improved bean varieties, comparing farmers who face adverse climate conditions with farmers who do not.

2 Methodology

This section presents the sampling methodology and distribution of the effective sample. It also includes information related to the implementation of field activities and the analysis carried out.

2.1 Sampling and sample distribution

We obtained the data through a survey of 590 farmers of different departments and municipalities in Nicaragua. We followed a two-stage sampling process using data from the IV National Agricultural Census conducted in 2011 by the National Institute of Development Information (INIDE) and the Ministry of Agriculture and Forestry (MAGFOR). The census lists 137,879 bean-producing agricultural holdings[6] (or "*explotaciones agropecuarias*") in 17 departments and 153 municipalities (Table A 1).

In the first stage, we identified 66 municipalities that contained 700 or more agricultural holdings (AH), and within these, the distribution of the 100 villages to be sampled (i.e., # of villages/municipality),

[5] Calderón, R. 2019. Personal communication via e-mail on 9/13/2019.

[6] According to INIDE and MAGFOR (2012), an agricultural holding is considered as a land destined for agricultural production (partial or total), and that is exploited as a technical and economic unit within a municipality.

following the random process described in Annex 1.[7] We decided to focus on municipalities with a minimum number of AH because as this number decreases, the geographical dispersion of the AHs will most likely increase, making it more difficult and expensive to find bean-producing households to survey. Further, we expected that growing beans was less important in municipalities with fewer bean-producing AHs.

In the second stage, we identified the 100 villages following the process described in Annex 2. Once we identified each village, field supervisors randomly sampled six households per village, equally distributed within the village.

In total, we identified 40 municipalities and 100 villages for the study (Table A 1) and expected to identify 600 households. However, one village could not be visited, and four households within three other villages could not be interviewed for different reasons. Thus, we were only able to complete 590 interviews (Figure 1). In this report, data used were obtained from 589 producers because we decided to omit information from one producer for having experimental bean plots (with small areas and extremely high yields), of which 341 were in the dry corridor and 248 in the non-dry one.

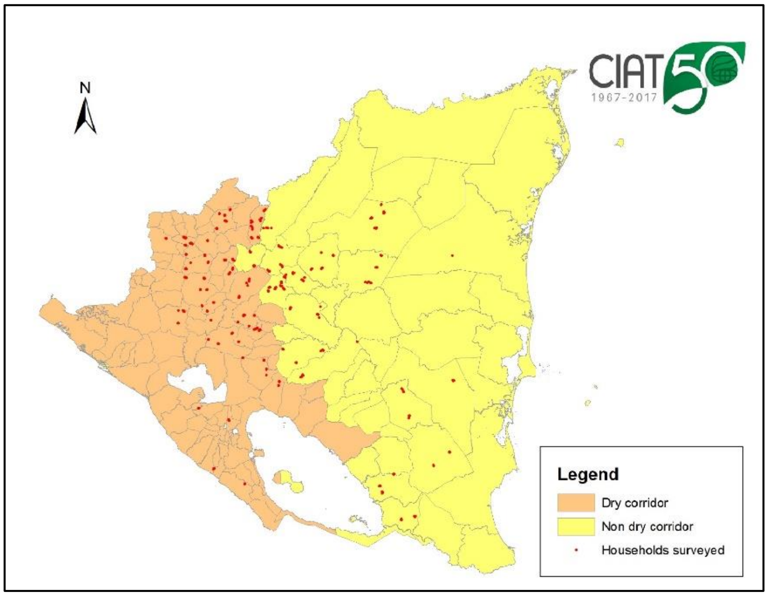


Figure 1. Distribution of interviewed bean-producing households in the dry corridor (dark-colored) and elsewhere

2.2 Instruments, data collection and analysis

We collected data thru face-to-face interviews using a structured instrument prepared for this purpose. The respondent was an adult with the most knowledge about bean crop management in the household. The instrument contained ten sections with questions about the respondent and household characteristics, farm details, bean, and other crops production information, sources of income, adverse events, among other information. The agricultural data refers to the planting dates August 2016 - July 2017, that is Postrera 2016, Apante 2016/2017, and Primera 2017.

[7] Due to different reasons (i.e., safety, inaccessibility), the following # of villages were re-distributed from one municipality to another: in Nueva Segovia the only village that was to be identified from Jalapa was assigned to Jícaro; in Madriz the only village from Telpaneca was assigned to Palacagüina; in León the only village from Santa Rosa del Peñón was assigned to El Sauce; in Jinotega all villages from San José de Bocay were assigned to Santa María de Pantasma (2 villages), San Rafael del Norte (1 village), San Sebastián de Yali (1 village) and Jinotega (1 village); in Río San Juan the only village from El Castillo was assigned to San Miguelito; in RAAN the two villages from Waspán were assigned to Waslala and the three villages from Puerto Cabezas were assigned to Waslala (1 village) and Mulukuku (2 villages); and in RAAS the only village from El Tortuguero was assigned to Muelle de los Bueyes.

To conduct the interviews, we trained a group of enumerators in Jinotega from 23-26 November 2017. These enumerators had ample experience in data collection in general and with agricultural surveys in particular, as they were part of a pool of enumerators the authors regularly use for data collection (hence extensive training was not necessary). Field data collection lasted 22 days, from November 27 thru December 18. After data cleaning, we used descriptive statistics to analyze the data that we present in this document. As a next (future) step, we will conduct econometric analysis to understand the determinants of improved varieties' adoption.

The analysis was disaggregated by two variables: adoption of improved varieties and location of the household; the latter to contrast farmers who may have faced adverse weather (rainfall and temperature) conditions (in the dry corridor) with farmers who may have not (not in the dry corridor). In this study, we define adoption as a farmer reportedly growing at least one improved variety during the period of reference in his/her farm.

Finally, we classified a household in the dry corridor if the household was located in any of the municipalities listed in this region by Van Deer Ze Arias et al. (2012). They defined the dry corridor by comparing information on climatic factors, threats of droughts, and anomalies in maize production. The information on these factors corresponds specifically to the map of dry months (CIAT[8] and PREVDA[9] atlas), precipitation of each country, and the Holdridge life zones system, which merges ecological factors related to the development of vegetation types and the development of organic life. Using this methodology, they classified the dry zones of Central America, which included 108 municipalities in Nicaragua. These authors further classified the dry corridor into three groups (municipalities with low, high, and severe weather effects) based on variables such as precipitation, number of dry months, evaporation, and location characteristics. Due to concerns with sample size, we did not follow this classification. Instead, we pooled all households in these three groups into one that we called the 'dry corridor', and all other households in another group outside the dry corridor called 'non-dry corridor'. In our sample, 24 municipalities were in the dry corridor and 16 in the non-dry corridor. The list of municipalities from our study in the dry corridor is included in Table A 2.

3 Farmer and household characteristics in the 2016-2017 seasons

3.1 Socioeconomic characteristics of respondent farmers and household head

The respondents were 45 years old, 84% were male and had completed 3.6 years of formal education (Table A 3). Slightly over one-half (52.3%) reported living in the village since birth, which was statistically significantly more common in households in the dry corridor. Roughly 15% of respondents reported being a member of at least one farmer organization, independently of the region where they lived (i.e., dry vs. non-dry regions). Participating in such groups plays an important role since small producers can obtain profits from these cooperatives, such as market opportunities, negotiation capacity, and access to information, technologies, and innovations (FAO, 2011)[10]. Although respondent farmers had almost 24 years of experience growing beans, farmers in the dry corridor had statistically more experience in the crop than farmers elsewhere.

[8] Centro Internacional de Agricultura Tropical

[9] Programa Regional de Reducción de la Vulnerabilidad y Degradación Ambiental

[10] Online available at: http://www.fao.org/news/story/es/item/93819/icode/

Most (86%) respondents were the household head. The household's head was, on average, 47 years old, 91% were men, had completed 3.3 years of formal education, and had 26 years of experience growing beans (Table A 3). Farmers in the dry corridor had three years more experience growing beans than who are in the non-dry corridor (Figure 2).

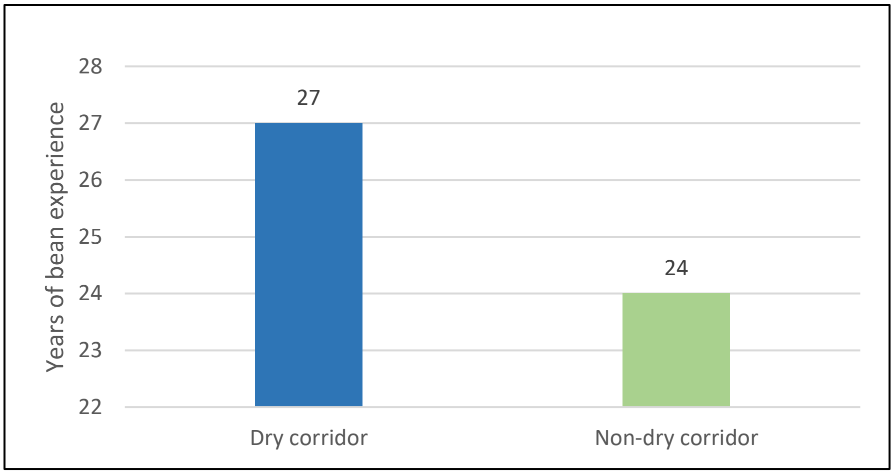


Figure 2. Years of bean experience of the household head

3.2 Characteristics of the household

The average Nicaraguan sampled household was composed of five members (Table A 3), of whom approximately three were men and two women. We estimated the economic burden among household members using a dependency rate[11], finding that households had a little over one non-dependent adult for every dependent member. The dependency rate was statistically significantly lower in households in the dry corridor (Figure 3), and this may have different implications, depending on the age of the dependent. For example, if the dependents are not too young nor too old (e.g., 14-17 years old), they could help with field activities. Further, if the dependents are old, they may have acquired some social status within their village, which may provide some profits for the household. In contrast, children require more supervision from adults, which may limit the time they could dedicate to field activities, potentially having a negative effect on crop output.

Since we did not collect detailed income data, we proxy wealth by the amount of assets in a household, as when households become richer, they invest in more and diverse assets. For this, we created indices using Principal Component Analysis (PCA), following the methodology described by Filmer and Pritchett (2001), McKenzie (2005), and Reyes et al. (2010). To better understand the diverse categories of assets, we estimated five indices: (i) a **technology index**, using information about having received technical assistance, using seed of improved varieties, inputs, or agricultural loans. (ii) An **infrastructure index**, using

[11] Estimated by dividing the total number of people from 0 to 17 years old and those over 65, by the total number of people aged 17 to 65.

information about the availability of water reservoirs or tanks, irrigation systems, or a warehouse. (iii) A **productive/transportation assets index**, with information about the ownership of a manual backpack sprayer, tractor, plow, bicycle, motorcycle, or a car. (iv) A **household assets index**, with information about the ownership of ten assets regularly used at home (e.g., television, cell phones). And (v) a **service index**, with information about the availability of potable water service, electricity, and access to the internet. By construction, the average is zero, and a positive value represents a greater availability of this type of goods. Therefore, one can assume a higher level of welfare (except perhaps for service assets, as this depends on public or private investment in service infrastructure, along with the capacity of the household to pay for these services).

The differences between farmers in the dry and non-dry corridors were not statistically significant for the technology and infrastructure indices. This suggests that (a) there is no advantage in the access to technology depending on the location; (b) despite potentially higher needs, farmers in the dry corridor do not have access to or have not invested in key water collecting or other types of infrastructure that may be beneficial for production; and (c) any differences in productivity may be due to other factors (e.g., weather, inherent knowledge, large productive assets). In contrast, farmers in the dry corridor had more access to productive/transportation and household assets and services (Figure 4). The difference in productive/transportation assets may influence crop-related decisions, productivity, and profits. For example, farmers with a vehicle may sell surplus directly in larger market places obtaining better prices. These results suggest that farmers in the dry corridor may be better off for household assets and services than elsewhere.

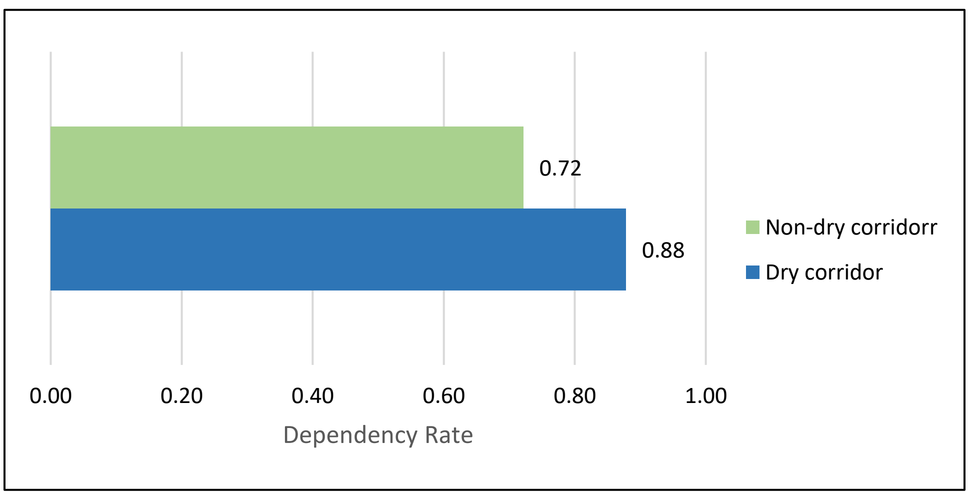


Figure 3. Economic dependency rate

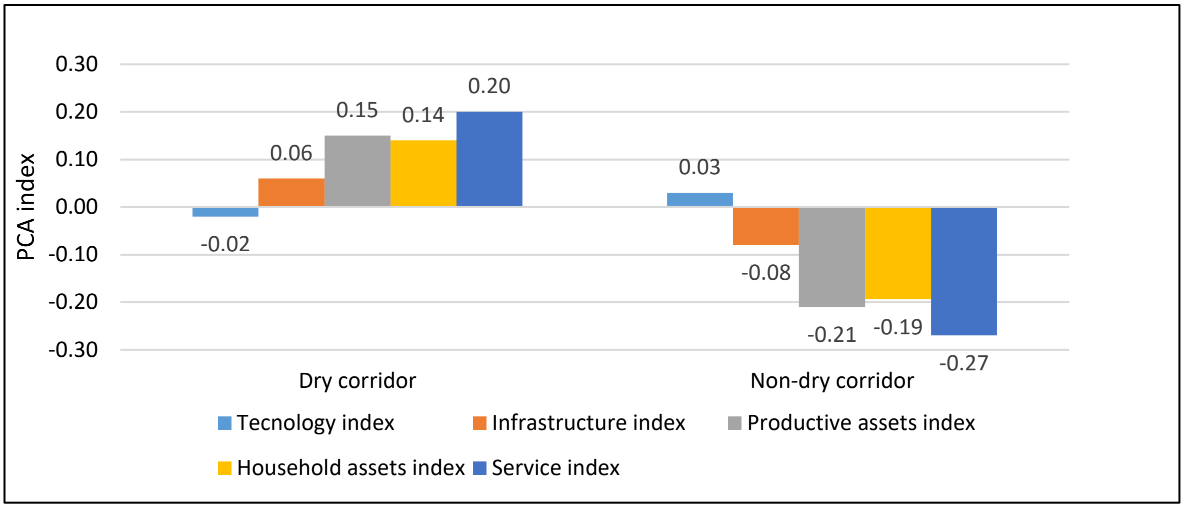


Figure 4. Household's asset indices

Another indicative of wealth relates to the amount of small, medium, and large animals owned, which farmers can sell to obtain quick cash. To analyze this, we estimated the number of Tropical Livestock Units (TLU)[12] to compare different types of animals in a standardized way across households. The households within the dry corridor had a statistically significantly lower number of TLU compared to those in the non-dry corridor (Figure 5). This possibly because of the adverse conditions related to strong droughts, which may make owning animals a risky business as they may be vulnerable to food availability and adequate conditions (Orgaz, 2019).

Other household characteristics studied included the fuel used for cooking, annual bean consumption that is satisfied by own production, how long bean reserves last, the frequency with which beans are cooked, and whether the household experienced periods of food scarcity (Table A 3). Most (>97%) households in the sample used wood as the primary fuel for cooking, they reported that 92% of annual consumption was satisfied by their own production (higher in the dry corridor), and 81% mentioned that their bean reserves lasted all year (higher in the dry corridor). On average, households cooked beans every two days (3.4 times during the week), and one out of every eight households reported that between January 2016 and January 2017, in at least one month, food was not enough to satisfy household needs.

[12] We used the tropical cattle unit to unify the number of livestock of different species converted to a common unit. The equivalences that were used are: livestock = 0.7; buffalo = 0.6 and pigs = 0.25 (FAO, 2011). We used the conversion factors for Central America for cattle and pigs; for buffalo, the equivalence of "others" was used because there was no conversion factor for the region.

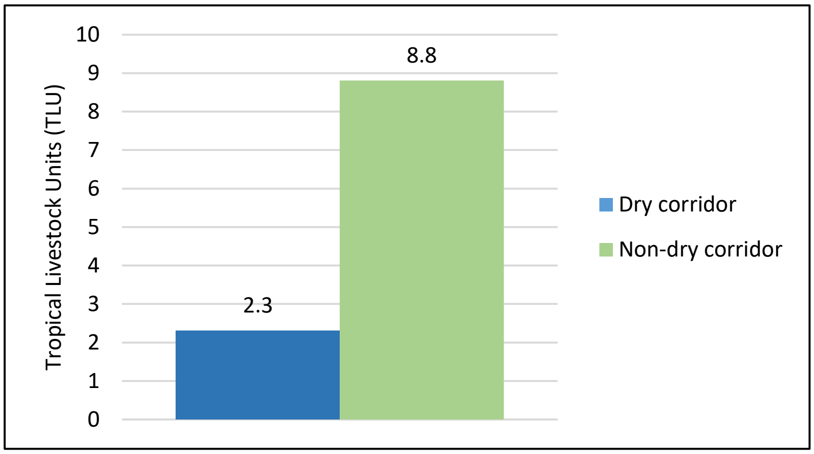


Figure 5. Tropical Livestock Units owned by the households

3.3 Sources of income in the household

We asked respondent farmers about the main sources of income in the household in the last season when beans were grown within the reference period. The most important sources were agriculture-related, and among these, bean sales was the primary one (30.5%), followed by selling their labor in agricultural activities off-farm (17.8%), sale of crops other than beans (16.8%), livestock-related activities (14.7%), selling labor in non-agricultural activities (11.4%), and other sources[13] (Figure 6). While bean sales and selling labor in non-agricultural activities were statistically significantly more important sources of income in the dry corridor, the sale of other crops and livestock activities were more important sources in the non-dry corridor. Further, selling labor off-farm in agricultural activities was equally important regardless of the region. The results confirm that livestock may be a less important income generation activity among bean producing households in the dry corridor due to potential limitations of the soils in this area, especially in the dry season, and their low productivity systems (Murillo, 2017).

[13] Other sources include sale of assets, remittances from relatives and any other source.

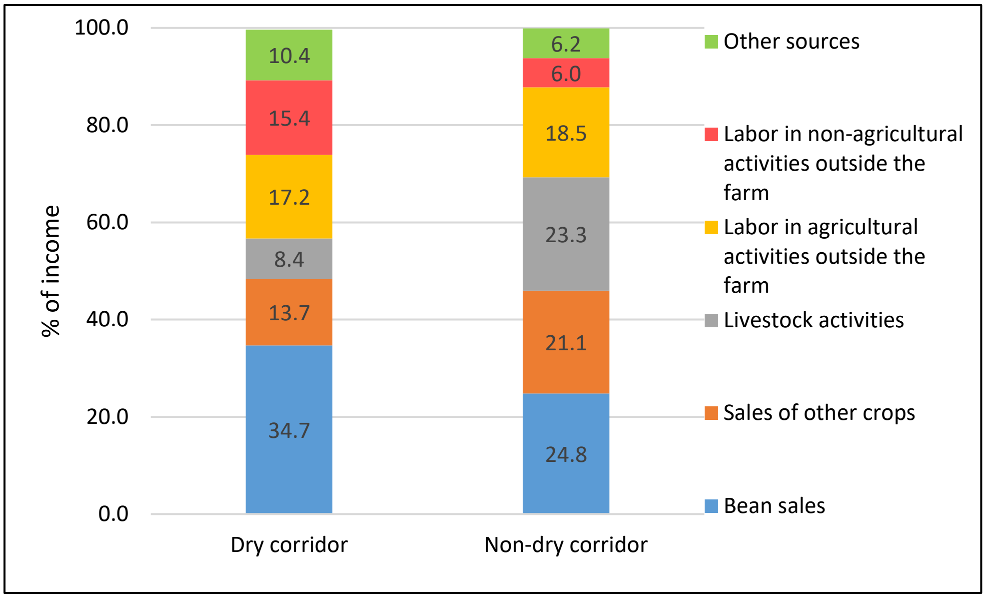


Figure 6. Sources of income in the household

3.4 Characteristics of the farm

The average farm size was almost 15 manzanas (mz[14]) of land, most of which was owned by the farmers (Table A 4). Farm size in the dry corridor was statistically significantly smaller than households elsewhere, as was the amount of land owned. Only a small share of all land (almost 15% of cultivated land) was dedicated to annual crops, including beans.

The typical farmer used almost 82 lbs of planting material per manzana, and this amount was statistically significantly higher among farmers in the non-dry corridor. On average, farmers planted slightly less than two varieties of beans, mostly self-reported traditional varieties. The number of improved and traditional varieties grown was significantly higher among households in the dry corridor (Table A 4).

[14] 1 mz=7,000 square meters

4 Adoption of improved bean varieties and crop management in the 2016-2017 seasons under adverse weather conditions

Improved varieties are varieties developed by breeders in the formal systems (Maredia and Reyes, 2014), with particular characteristics that make them attractive to farmers, such as resistance to diseases, high yield potential and lower use of inputs. Following the definition of adopters of improved varieties (IVs) detailed above, we next present results comparing adopters vs. non-adopters and how adoption levels changed by region.

4.1 Varietal and seed management

We estimated the adoption of improved bean varieties in two ways. First, if a household adopted at least one improved variety, we classified it as an adopter. Second, we estimated the share of the area under improved varieties, as some farmers who reported growing IVs also grew traditional varieties. As shown in Table A 4, 30% of sampled households had adopted an IV, and 28% of the bean area was planted with improved bean varieties. The results suggest that the adoption of IVs was not statistically different between regions.

While there were no statistically significant differences between adopters and non-adopters in the total land cultivated, land owned, or land with annual crops, IV adopters planted more area with beans and used less planting material (perhaps reflecting better germination rates of IVs) than non-adopting households (Table A 4). We further observed differences in several socioeconomic characteristics between adopters and non-adopters. Adopters had completed more years of formal education, more participated in farmer groups, had more experience (years) growing beans, were more dependent on beans as the main source of grain for consumption, their bean reserves lasted longer, cooked beans more frequently, and faced less food insecurity (Table A 3).

Table 1 shows the ten most commonly grown varieties, which together account for slightly more than 60% of the bean area. The most commonly grown IV was INTA Rojo (17.1% of the bean area), followed by 'Rojo' beans (traditional variety) and INTA Sequía (an IV). While there were other improved varieties grown, none accounted for a significant amount of area compared to the two mentioned above. INTA Rojo is an improved variety released in 2002 and characterized by its capacity for high yield and tolerance to drought and light red color (INTA, 2010). Finally, a very small number of farmers grew beans intercropped, and intercropping beans were more common in the dry corridor, regardless of whether the variety was improved or traditional (Table A 4).

Table 1. Most popular bean varieties grown in all seasons during the period of reference

Variety	Land planted with variety	
	Manzanas	%
INTA Rojo	234.3	17.1
Rojo	160.3	11.7
INTA Sequia	88.0	6.4
Rojo Claro	76.8	5.6
Nica	58.8	4.3
INTA Norte	49.5	3.6
H vaina blanca	45.8	3.3
Chile rojo	44.8	3.3
H vaina roja	39.5	2.9
Negro	39.3	2.9
All other varieties	532.7	38.9

*Land planted includes all seasons; 1 manzana=7,000 sq.m.

4.2 Other bean management practices, by IV adoption and region

Use of inputs

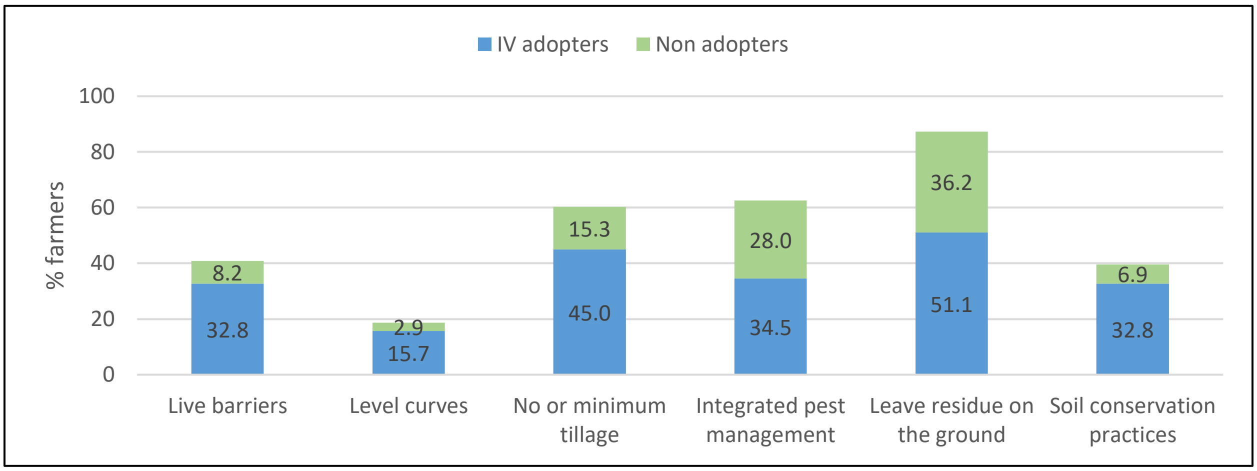
While most farmers managed only one bean plot, some had more than one plot, with an average of 1.2 plots per household (Table A 4). Among the chemical inputs used, the most common were herbicides, applied in 45% of the bean plots, and its use was significantly less common in the dry corridor. The use of fertilizers was similar regardless of the region, or if a farmer had adopted an improved variety: farmers applied fertilizer in 27% of the plots. In contrast, the use of insecticides and fungicides (though less common than using fertilizers) varied by region and IV adoption. While using insecticides and fungicides was more common in the dry corridor, farmers who adopted an IV used statistically significantly less insecticide and more fungicide than non-adopters. Using organic inputs was very limited for all groups.

Land conservation practices, technical assistance, and credit

We asked farmers about the adoption of management practices aimed at soil conservation for the bean plots used in the seasons of interest. From the six practices we inquired about, three were the most common—leaving crop residues on the ground (42% of plots), integrated pest management (30% of plots), and minimal to zero tillage (25% of plots). In general, the adoption of all six practices was statistically higher among IV adopters (Figure 7, top) and, except for the use of live barriers, among farmers in the dry corridor (Figure 7, bottom).

We also asked farmers about the technical assistance on bean crop management received during this period, focusing on seven topics: crop diversification, use of IVs, pest and disease control, best practices for bean management, irrigation and water management techniques, marketing and sales, and organizational skills (Figure A 1). Overall, few farmers (<10%) reported receiving technical assistance, and the most common topics were training on best practices for bean crop management (9.8%), crop diversification (8.7%), and pest and disease control (8.0%). This varied by adoption and to a lesser degree by region. While receiving training on all these topics was statistically significantly higher among adopting farmers, the only statistically significant difference between regions was on training about the use of IVs, higher among farmers in the dry corridor.

Regarding access to credit, 14.4% of farmers reported asking for agricultural credit during the period of reference. Although the share of farmers requesting credit was similar between regions (15.0% in the dry corridor and 13.7% in the non-dry corridor); it was statistically significantly higher among IV adopters—19.8% vs. 12.1% non-adopters. Among farmers who requested credit, most (91.8%) reported the credit was approved, and among these, 46.8% said they invested it in the bean crop. Access to credit could be key to improving agricultural productivity, as it facilitates investment in agricultural inputs and technology (Mohamed & Temu, 2008).



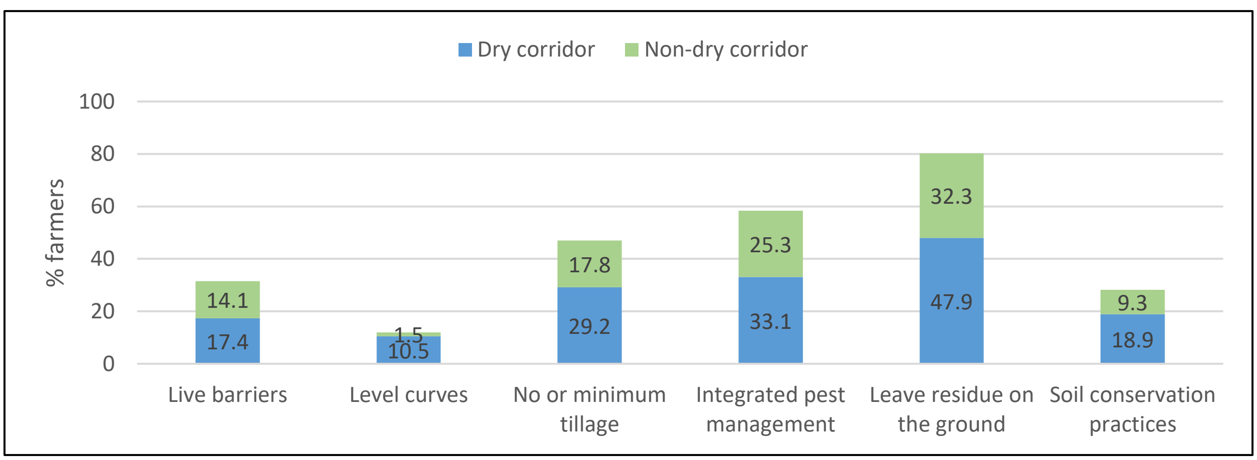


Figure 7. Management practices implemented agricultural plots by adoption (top) and region (bottom)

Bean production costs

We estimated production costs by adding the different types of expenses incurred during bean production for all seasons, including the cost of inputs and its transportation to the farm, cost of hired labor, and transaction costs, understood as transportation and management expenses required to sell their product. Figure 8 shows the total costs for adopters and non-adopters, and Figure A 2 shows the same by region. As can be appreciated, inputs account for most of the production cost. The input cost and total cost were statistically significantly higher among IV adopters and farmers in the dry corridor. When we estimated the cost per manzana planted and per quintal (qq)[15] harvested, we observed that while the cost per manzana was statistically similar between regions and IV adoption (average of C$2,203/mz), the cost per qq was significantly higher in the dry corridor (C$402/qq vs. C$216/qq), most likely due to the significantly higher use of purchased inputs in this region.

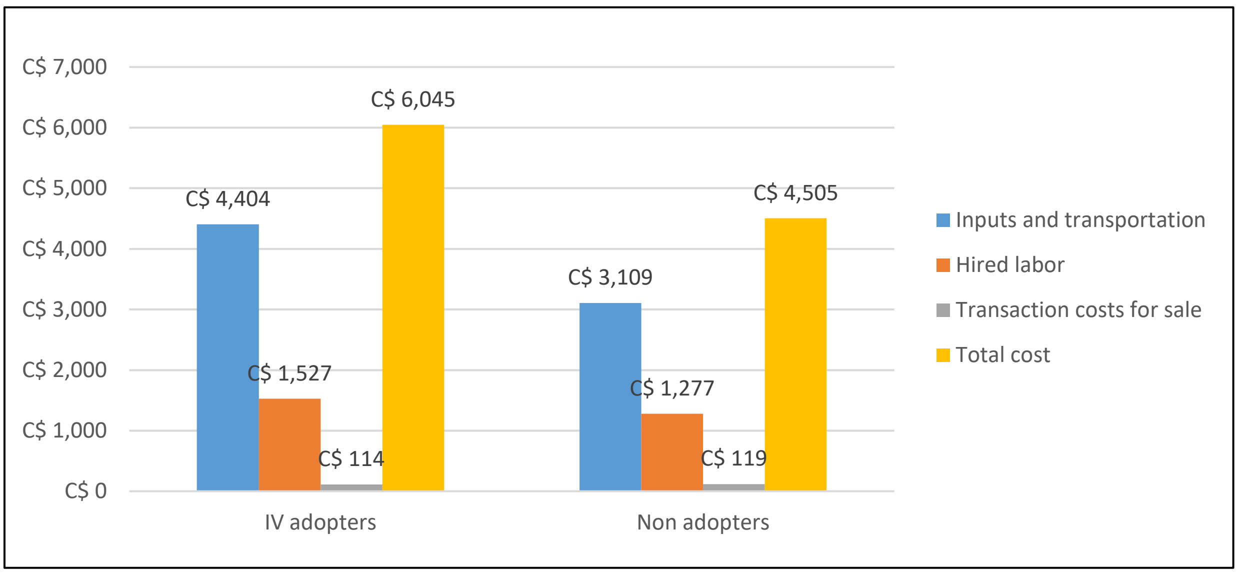


Figure 8. Total production cost (Cordobas) in all seasons, by adoption of IVs

Adverse weather events

During the year of reference, some adverse effects occurred that significantly affected farmers. The most common event reported was irregular rains (17% of farmers), followed by droughts (11.9%) and storms (11.7%). While storms affected a statistically significantly higher share of IV adopters and households in the non-dry corridor, irregular rains were significantly more common among non-adopting households. Regarding droughts, it was surprising that only a small share of farmers reported they experienced a

[15] 1 qq =100 pounds

drought during the agricultural year of interest. However, rainfall data from CCAFS-Climate[16] for the seasons of interest show that precipitation was 672 mm[17] in Postrera 2016, 181 mm in Apante 2016/17 and 668 mm in Primera 2017, which except for the Apante season, is well above the 300-350 mm of water the bean crop needs (Rosas, 2003), thus confirming this finding. Rainfall data further show that while both IV adopters and non-adopters faced similar amounts of rain (Figure 9, top), rainfall in the dry corridor was lower than in the non-dry corridor (Figure 9, bottom).

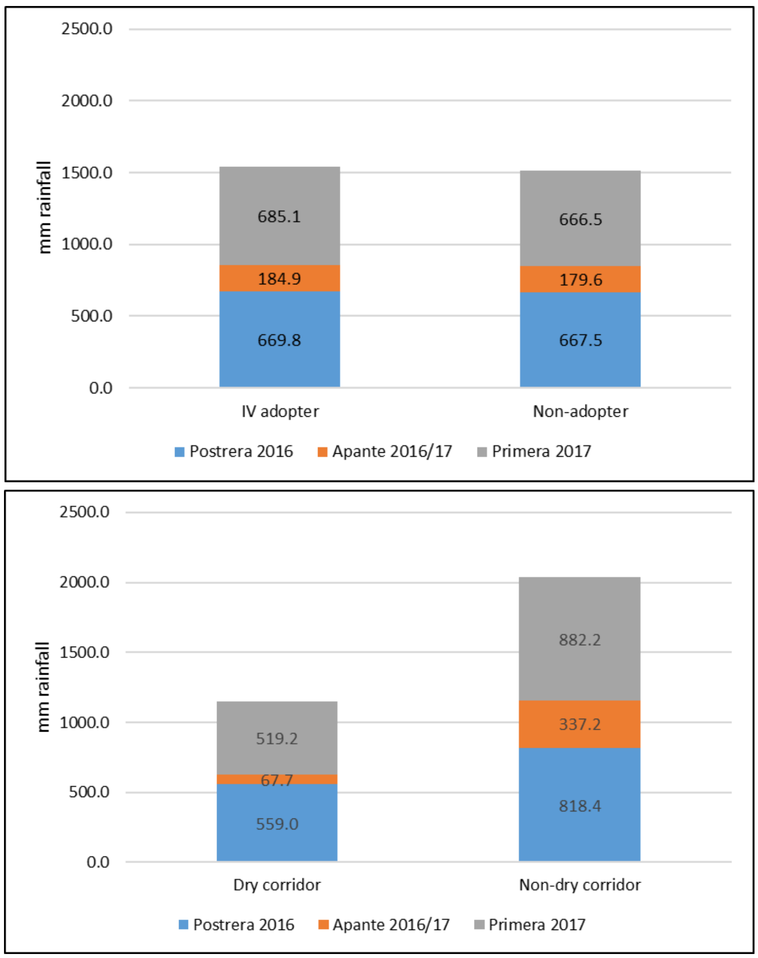


Figure 9. Rainfall distribution among adopters of IV and non-adopters (top) and region (bottom)

[16] Provides weather data from the nearest station using Global Positioning Location village-level survey data. Databases used include CHIRPS & WorldClim V2 & CRU TS V4 data. Online at: http://ccafs-climate.org/weather_stations/
[17] Millimeters of rain.

4.3 Bean production, utilization, and commercialization, by IV adoption and region

We estimated bean yields at the variety level, as many households grew both improved and traditional varieties. On average, farmers' yields were 12.4 qq/mz. Figure 10 shows that yields were statistically significantly higher in the non-dry corridor and among farmers who had adopted an improved variety. This is consistent with prior expectations, especially for farmers who adopt IVs, as we would expect them to obtain higher yields due to the increased yield potential of such varieties. Farmers located in regions with better environmental conditions obtained approximately 16% higher yields than farmers in drier regions. Further, adopting an improved variety translates into approximately 11% higher yields than planting a traditional variety.

The results suggest that these findings may be related to land conservation practices, use of inputs, rainfall, technical assistance, and other socioeconomic characteristics. For example, in the case of IV adopters, a larger share implemented land management practices spent more on inputs, more received technical assistance, planted more land to beans, had better access to household services (potable water, electricity, and internet), and experienced less food insecurity than non-adopting households, which all could have contributed to higher yields. In contrast, although more households in the dry corridor implemented land management practices, spent more on inputs, planted more land to beans, had better access to household services, and had more productive assets, this did not translate into higher yields, possibly because they experienced less rainfall and owned less land. The dry corridor is a very vulnerable region to climate change that may cause a decrease in yields because of its low precipitations and high temperatures (Bendaña, 2012).

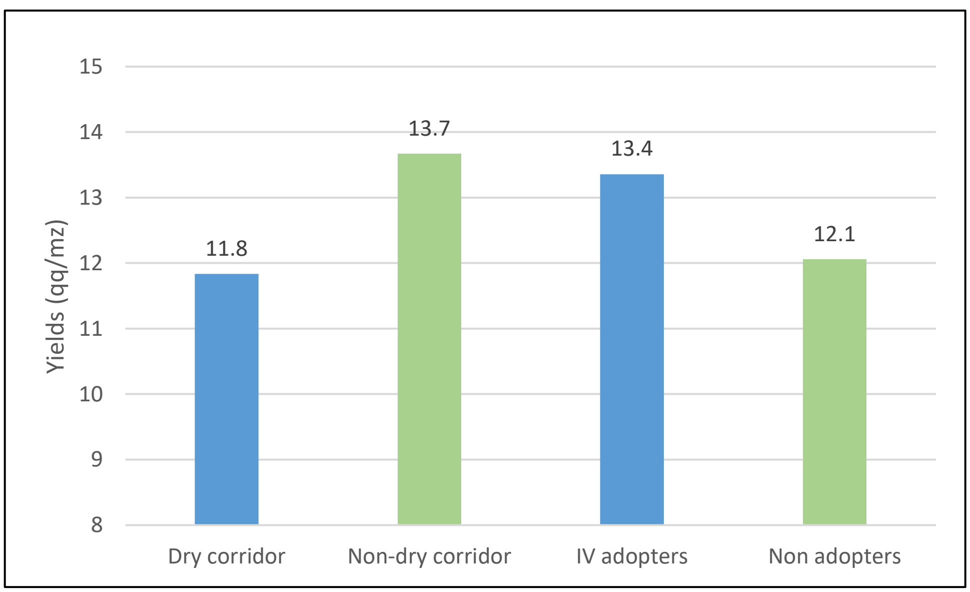


Figure 10. Bean yields (qq/mz), by region and IV adoption

We asked farmers what use they give to their bean harvest. Not surprisingly, most of the harvest was destined for own consumption (45%) and sale (43%). Farmers left 8.2% of their harvest to use as seed the following season, and a small share (3.3%) was used for other purposes (Table A 5). When analyzing this information by region, we observed that the share of beans saved as seed for the next season and the share used for other purposes was statistically significantly higher among households in the dry corridor. Further, while non-adopter households saved significantly more of their harvest to use as seed and for their consumption, they sold a smaller share than IV adopters.

On average, 66.9% of households reported selling part of their bean harvest, and this was statistically significantly higher among IV adopters (77.4%) than non-adopters (62.4%). Among households that sold beans, they sold an average of 64.6% of the amount harvested, and the differences between adopters and non-adopters or regions were not statistically significant at the 10% level. However, the quantity sold by households that sold beans was statistically higher for IV adopting households (32.0 qq vs. 24.6 qq non-adopters) and households in the dry corridor (31.5 qq vs. 21.2 qq elsewhere), with an average of 27.2 qq sold by all households (Figure A 3).

Bean sales translated into an average profit of C$19,242 (roughly US$654).[18] Figure 11 shows the total profits by IV adoption and region. While the differences were not statistically significant between adopters and non-adopters, farmers in the dry corridor obtained statistically significantly higher profits than farmers elsewhere. This was because farmers in the dry corridor sold much more beans at a slightly higher price (C$891/qq, vs. C$867/qq in the non-dry corridor). By contrast, although IV adopters sold more beans than non-adopters, they reported a lower price (C$867/qq, vs. C$890/qq by non-adopters), why the differences in profits for this group were not statistically significant.

[18] Average exchange rate from Central Bank of Nicaragua (August 1, 2016-July 24, 2017) was C$29.43/US$.

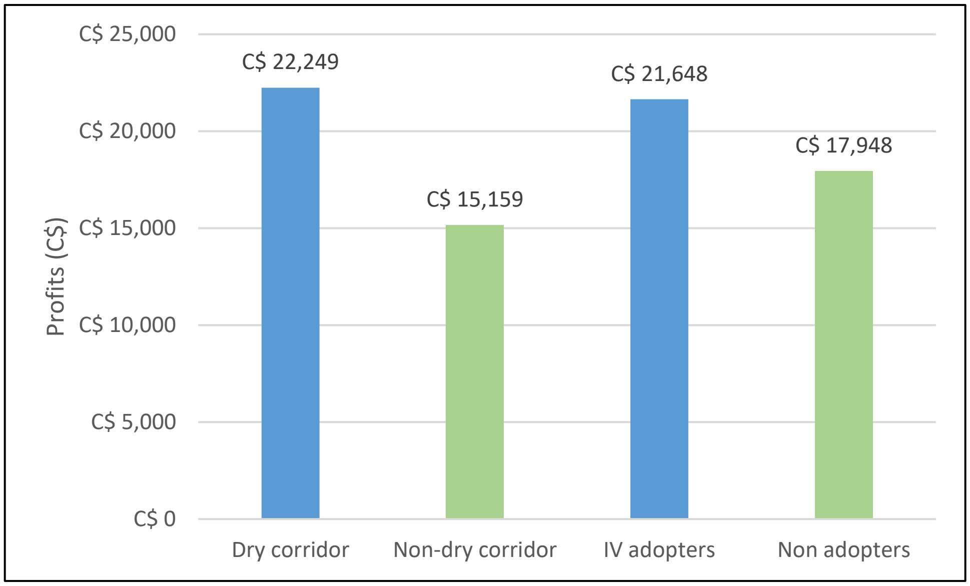


Figure 11. Total profits (Cordobas), by region and IV adoption

4.4 Adoption of IVs under adverse weather conditions

To better understand adoption rates, we analyzed IVs adoption within each region because we expected adoption to differ in regions with adverse production conditions (i.e., adverse abiotic and biotic factors). In this section, we focus our discussion on yields and profits. As discussed above, farmers obtained an average of 12.4 qq/mz. Although we did not observe statistical yield differences in adopting an IV under good rainfall conditions (i.e., non-dry corridor), farmers who adopted an improved bean variety in the dry corridor (where they faced lower precipitation) obtained 13.2% higher yields than farmers who did not adopt an IV under these adverse production conditions (Figure 12). This most likely is because, under adverse conditions, improved varieties express their better traits (such as drought tolerance and disease resistance) compared to traditional (susceptible) varieties.

When analyzing profits, although IV adopters obtained a higher value than non-adopters within the dry corridor. This difference was not statistically significant at the 10% level (Figure 13), suggesting that even though adopting farmers in this region secure higher yields, this does not necessarily translate into higher profits (though higher yields could translate into higher food security). Finally, we also did not observe statistically significant differences between adopters and non-adopters in non-dry regions.

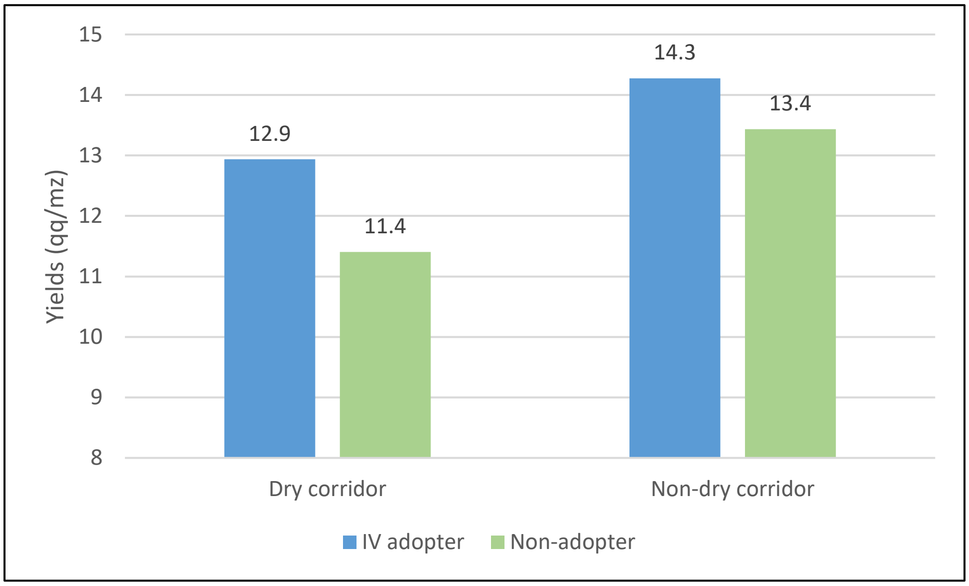


Figure 12. Yields (qq/mz) of adopting and non adopting farmers within each region

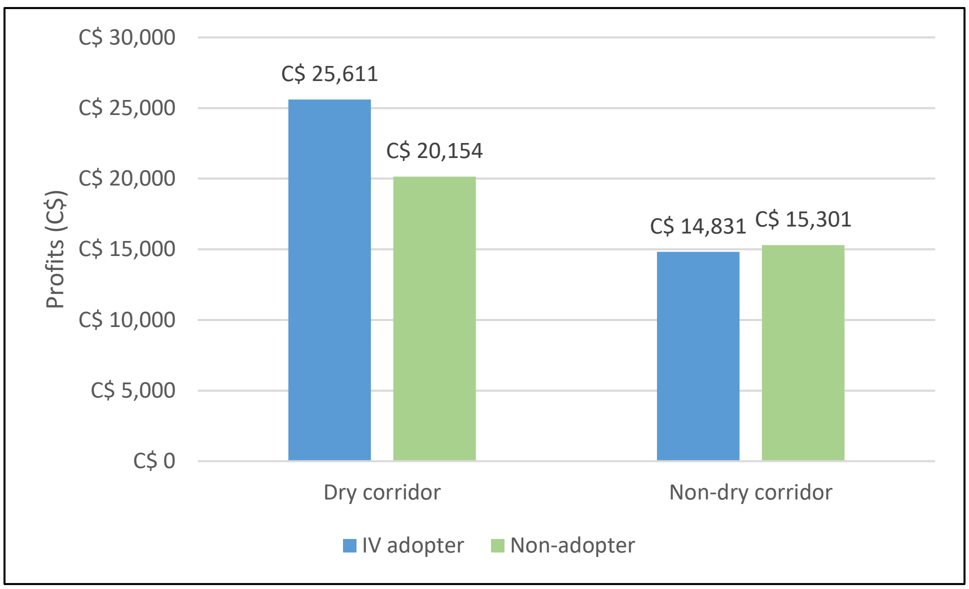


Figure 13. Profits (Cordobas) of adopting and non adopting farmers within each region

5 Concluding remarks

This study documents the situation of bean production in Nicaragua, where the crop is an important staple in the local diet and a source of revenue due to the local and regional trade. Using household-level data from a representative sample of 589 farmers (341 located in the dry corridor), we showed that there were statistical differences in the socioeconomic characteristics, farm characteristics, and bean management practices between IV adopters and non-adopters, and also by region (i.e., dry vs. non-dry corridors).

The results show that farmers in the dry corridor, facing adverse rainfall conditions, obtained significantly lower yields compared to farmers in non-dry areas. Further, we showed that 30% of farmers in Nicaragua had adopted at least one improved bean variety in the seasons of interest (August 2016-July 2017) and that 28.3% of the bean area was grown with IVs, which drastically contrasts the levels of adoption previously estimated by Reyes et al. (2016). Adopting an IV positively affected yields--farmers obtained 11% higher yields than non-adopters. However, this did not translate into obtaining higher profits.

Farmers reported growing more than fifty varieties, but only ten occupied a large part of the total planted area. The most commonly grown variety (regardless of whether it was improved or not) was INTA Rojo, which is consistent with previous findings by Reyes et al. (2016). Other commonly grown IVs were INTA Sequía and, to a lesser extent INTA Norte.

Finally, this study confirms the importance of improved varieties under adverse rainfall conditions, as farmers who adopted an IV in the dry corridor obtained 13.2% higher yields than non-adopters in the same region, although this did not mean higher profits. We did not find statistical yield differences between IV adopters and non-adopters in non-dry regions. Next, we plan to carry out further analysis to understand the determinants of adoption and, more accurately, the effect of IVs after controlling for other factors that can affect yields and the economic impact on farmers.

6 References

Araya, R., Rodríguez, R., Molina, J., & Ramos, F. (1992). Variedades mejoradas de frijol (Phaseolus vulgaris L.): concepto, obtención y manejo. In J. H. Tobón Cardona, Curso internacional sobre frijol (Phaseolus vulgaris) en Zona de Ladera de la Región Andina. Rionegro, Antioquia.

Asamblea Nacional de Nicaragua. (2014). Ley reguladora de la producción, comercialización, investigación, importación y exportación de semillas. Managua. Available at: http://legislacion.asamblea.gob.ni/SILEG/Iniciativas.nsf/0/7e3971f9ed92e31406257cc200570f08/$FILE/Iniciativa%20de%20Ley%20Reguladora%20de%20la%20Producci%C3%B3n,%20Comercializaci%C3%B3n%20.....Semillas.pdf

BCN (Banco Central de Nicaragua). (2017). Plan de producción, Consumo y Comercio, ciclo 2017-2018. Managua, Nicaragua.

Bendaña, G. 2012. Agua, agricultura y seguridad alimentaria en las zonas secas de Nicaragua. Managua, Nicaragua.

FAO (Food and Agriculture Organization of the United Nations). 2011. Guidelines for the preparation of livestock sector reviews. Animal Production and Health Guidelines. No. 5. Rome.

Filmer, D. and L.H. Pritchett. (2001). Estimating Wealth Effects without Expenditure Data-or Tears: An Application to Educational Enrollments in States of India. Demography, Vol 38 (1): 115-132.

IICA (Instituto Interamericano de Cooperación para la Agricultura) -Red Sicta. (2013). Estudio de las cadenas de valor maíz blanco y frijol en Centroamérica. Managua, Nicaragua.

INIDE (Instituto Nacional de Información de Desarrollo), MAGFOR (Ministerio Agropecuario y Forestal de Nicaragua). (2012). IV CENAGRO (Censo Nacional Agropecuario). Managua, Nicaragua.

INTA (Instituto Nicaragüense de Tecnología Agropecuaria). (2010). INTA ROJO, Variedad Mejorada de Frijol Rojo. Available at: http://www.funica.org.ni/docs/gran_basic_20.pdf (Accessed on 11 July 2019)

MAGFOR (Ministerio Agropecuario y Forestal de Nicaragua), INTA (Instituto Nicaragüense de Tecnología Agropecuaria). (2014). Catálogo de cultivares de granos básicos. Managua, Nicaragua.

Maredia, M., Reyes, B., 2014. Guidelines for collecting varietal release and adoption data Objective 2.1. “Organize the collection of crop germplasm improvement research related direct outcomes”. Strengthening impact assessment in CGIAR (SIAC) project.

McKenzie, D. J. (2005). Measuring Inequality with Asset Indicators. Journal of Population Economics, Vol 18 (2): 229-260.

Mohamed, K., & Temu, A. (2008). Access to Credit and Its Effect on the Adoption of Agricultural Technologies: The Case of Zanzibar. African Review of Money Finance and Banking, 45-89. Available at: http://www.jstor.org/stable/41410533

Murillo, M. (2017). Ayuda Memoria Misión Corredor Seco de Nicaragua (P162982). Available at: http://pubdocs.worldbank.org/en/190611503940922739/pdf/AM0mision0de0i0oyecto0Corredor0Seco_1.pdf

Orgaz, C. (2019, May 15). ¿Qué es el Corredor Seco y por qué está ligado a la pobreza extrema en casi toda Centroamérica? BBC News. Available at: https://www.bbc.com/mundo/noticias-america-latina-48186820

Reyes, A. E. (2007). Guía de seguridad alimentaria y nutricional para uso del personal agropecuario de Nicaragua. INTA (Instituto Nicaragüense de Tecnología Agropecuaria), Managua (Nicaragua). FAO (Organización de las Naciones Unidas para la Alimentación y la Agricultura), Managua (Nicaragua). PESA (Programa Especial para la Seguridad Alimentaria), Esteli (Nicaragua)

Reyes, B.; Donovan, C.; Kelly, V. (2010). Baseline Survey Report. Raising the Incomes of Smallholder Farmers in the Central Highlands of Angola: A Model Project for Improving Agricultural Value Chains in Post-Conflict Nations. ProRenda Project. Report submitted to World Vision. 70 p.

Reyes, B., Maredia, M.K., Bernsten, R. and Rosas, J.C. (2016). Opportunities Seized, Opportunities Missed: Differences in the Economic Impact of Bean Research in Five Latin American Countries. MSU International Development Working Paper No. 151.

Rosas, J.C. 2003. El Cultivo del Frijol Común en América Tropical. 2da edición. Imprenta Litocom, Tegucigalpa, Honduras.

Van der Zee, A., Van der Zee, J., Meyrat, A., Poveda, C. & Picado, L. (2012) Estudio de la caracterización del Corredor Seco Centroamericano. FAO (Organización de las Naciones Unidas para la Alimentación y la Agricultura). Tegulcigalpa, Honduras

WHO (World Health Statistics). (2017). HarvestPlus internal database repository.

World Bank & CIAT. (2015). Climate-Smart Agriculture in Nicaragua. CSA Country Profiles for Africa, Asia, and Latin America and the Caribbean Series. Washington D.C.: The World Bank Group.

7 Annexes

Annex 1. Sampling process to identify the distribution (number) of villages per municipality

1. In one Excel® sheet (**“sheet 1”**), make a list of the municipalities with 700 or more agricultural holdings and their corresponding number of agricultural holdings (AHs).
2. Using the number of AHs, estimate the share per municipality by dividing the # of AHs in each municipality by the total (country) # of AHs.
3. Estimate the cumulative probability in percentage (step #2 * 100) and multiply by 100, to generate numbers in the thousands. We will use these values in step 9 below.
4. Note the maximum value generated in #3 above (N). This will be the maximum number of random numbers to be generated.
5. In another sheet (**“sheet 2”**), write <u>sequential numbers</u> from 1 to N. In a second column, use the RAND() function to generate <u>random numbers</u> between 0-1. Do this for each row up to N.
6. Since the random numbers vary every time the sheet is calculated, copy and paste (the values) these two columns in two new columns and continue as follows.
7. Sort by random number (both the sequential and random numbers) from smallest to largest.
8. Select n rows (120 in our case, as we needed 100 villages plus 20 replacement villages) sequentially, starting with the smallest random number. We are interested in the sequential numbers (N) associated with the random numbers.
9. Copy these n rows (only the sequential numbers) in **sheet 1.** Mark each time a municipality (values from step 3 above) contains the selected sequential number. This will give you the (a) sampled municipalities and (b) number of villages to sample per municipality, but not the names (as we did this separately, as explained in Annex 2).

Annex 2. Process to sample villages within each municipality

1. Once we determined the distribution (#) of villages per municipality from Annex 1, the next step was to sample the villages. For each sampled municipality, we listed all villages in Excel using information from http://www.inide.gob.ni/censos2005/CifrasMun/tablas_cifras.htm, in the same order as they appear in the link.
2. In each municipality, we numbered all villages from 1 to n (starting again in 1 in the next municipality).
3. Using the information from the first step (Annex 1) about the number of villages to sample per municipality, we divided n by this number to obtain an interval.
4. For each municipality, we generated a random number (function RANDBETWEEN()) between 1 and n (the maximum number of villages in the municipality), and copied and pasted the value (since the formula will generate a new number each time the file is opened) in a new cell. The village containing this random number was sampled.
5. Starting with the first sampled village (from step 4), we used the interval (from step 3) to identify all villages within each municipality. For example, if a municipality contained 56 villages and we needed to sample four, the interval was (56/4) 14. If the random number was 53, the village with this number was selected, as were the villages with numbers 11, 25 and 39.

Annex 3. Annex Tables and Figures

Table A 1. Census data, sampling frame, sample and effective sample

Department	Agricultural Holdings with beans (census)	Municipalities				Villages	
		Census	Sampling frame (≥700 AH)	Sampled	Effective	Sampled	Effective
Boaco	7,033	6	4	4	4	6	9
Carazo	3,722	8	3	1	1	2	1
Chinandega	2,530	13	0	0	0	0	0
Chontales	3,875	10	0	0	0	0	0
Esteli	7,523	6	5	3	3	10	10
Granada	2,059	4	1	0	0	0	0
Jinotega	20,018	8	7	6	6	16	12
Leon	3,591	10	3	1	1	2	2
Madriz	8,781	9	6	4	4	4	8
Managua	3,672	9	1	1	1	2	1
Masaya	3,301	9	1	1	1	1	1
Matagalpa	20,118	13	10	8	8	19	22
Nueva Segovia	12,021	12	5	2	2	11	11
RACCN	15,119	8	6	3	3	11	11
RACCS	13,577	12	7	3	3	7	5
Rio San Juan	5,971	6	4	2	2	6	5
Rivas	4,968	10	3	1	1	3	1
Total	**137,879**	**153**	**66**	**40**	**40**	**100**	**99**

Source: IV CENAGRO (2012) and Survey Data.

Table A 2. Distribution of sampled municipalities and households

Department	Municipality	Dry corridor	# households
Boaco	Boaco	No	24
Boaco	Camoapa	No	6
Boaco	San Lorenzo	Yes	6
Boaco	Teustepe	Yes	18
Carazo	Santa Teresa	Yes	6
Esteli	Condega	Yes	18
Esteli	Esteli	Yes	30
Esteli	La Trinidad	Yes	12
Jinotega	El Cua	No	17
Jinotega	Jinotega	Yes	12
Jinotega	San Rafael del Norte	Yes	12
Jinotega	San Sebastian de Yali	Yes	12
Jinotega	Santa Maria de Pantasma	No	12
Jinotega	Wiwili de Jinotega	No	4
Leon	El Sauce	Yes	12
Madriz	Palacaguina	Yes	12
Madriz	Somoto	Yes	6
Madriz	Telpaneca	Yes	6
Madriz	Totogalpa	Yes	24
Managua	Managua	Yes	6
Masaya	Masaya	Yes	6
Matagalpa	Ciudad Dario	Yes	18
Matagalpa	El Tuma-La Dalia	No	30
Matagalpa	Matagalpa	Yes	24
Matagalpa	Matiguas	No	12
Matagalpa	Rancho Grande	No	18
Matagalpa	San Dionisio	Yes	18
Matagalpa	San Isidro	Yes	6
Matagalpa	Terrabona	Yes	6
Nueva Segovia	Jicaro	Yes	30
Nueva Segovia	Wiwili de Nueva Segovia	Yes	35
RACCN	Mulukuku	No	18
RACCN	Siuna	No	24
RACCN	Waslala	No	24
RACCS	El Rama	No	6
RACCS	Muelle de los Bueyes	No	12
RACCS	Nueva Guinea	No	12
Rio San Juan	San Carlos	No	12
Rio San Juan	San Miguelito	No	18
Rivas	Tola	Yes	6
Number of households			**590**

Table A 3. Socioeconomic characteristics of respondent farmers, household heads and the household

Characteristics of…	Region		Adoption		Total
	Dry corridor	Non-dry corridor	IV adopter	Non-adopter	
Respondent:					
Age (years)	45.9 (14.7)	44.3 (14.5)	44.9 (14.7)	45.4 (14.6)	45.2 (14.6)
Male (% yes)	84.7 (0.4)	81.8 (0.4)	83.6 (0.4)	83.5 (0.4)	83.5 (0.4)
Years of formal education completed	3.8 (3.9)	3.3 (3.6)	**4.1 (3.9)***	**3.4 (3.8)***	3.6 (3.8)
Living in the community since birth (%)	**66.7 (47.2)*****	**33.1 (47.1)*****	57.1 (49.7)	50.5 (0.5)	52.5 (0.5)
Member of farmers group(%)	15.2 (0.4)	14.5 (0.4)	**20.9 (0.4)*****	**12.4 (0.3)*****	14.9 (0.4)
Years growing beans	**25.1 (15.5)****	**22.6 (14.2)****	**26.2 (16.7)****	**23.1 (14.1)****	24.0 (14.9)
Was the household head (% yes)	85.9 (0.3)	85.4 (0.4)	85.3 (0.4)	86.0 (0.3)	85.7 (0.3)
Number of observations	**341**	**248**	**177**	**412**	**589**
HH head:					
Male headed HH (%)	91.2 (0.3)	90.3 (0.3)	93.8 (0.2)	89.6 (0.3)	90.8 (0.3)
Mean age (years)	47.9 (14.12)	46.3 (15.1)	46.6 (14.5)	47.5 (14.6)	47.2 (14.5)
Mean education (years)	3.6 (3.7)	3.2 (3.5)	**3.7 (4.0)****	**3.1 (3.5)****	3.3 (3.7)
Years growing beans	**26.8 (15.3)***	**24.4 (14.4)***	**28.6 (16.4)*****	**24.6 (14.1)*****	25.8 (14.9)
Number of observations	**341**	**248**	**177**	**412**	**589**
Household:					
Dependency ratio	**0.72 (0.6)*****	**0.87 (0.6)*****	0.75 (0.6)	0.80 (0.6)	0.78 (0.6)
Household size (n)	4.8 (2.0)	4.8 (1.9)	4.7 (1.8)	4.9 (2.0)	4.8 (1.9)
Use wood for cooking (% yes)	96.7 (0.2)	98.8 (0.1)	98.3 (0.1)	97.3 (0.2)	97.6 (0.2)
Annual bean consumption that comes from own production (%)	**93.3 (17.5)***	**90.5 (21.6)***	**95.8 (13.9)*****	**90.6 (20.9)*****	92.1 (19.2)
Bean grain reserves last whole year (% yes)	**82.9 (0.4)***	**77.4 (0.4)***	**88.1 (0.3)*****	**77.4 (0.4)*****	80.6 (0.4)
Food was not enough to satisfy needs in at least one month between January 2016 and 2017 (% yes)	13.2 (0.3)	11.7 (0.3)	**8.5 (0.3)****	**14.3 (0.4)****	12.6 (0.3)
# of times you cooked beans within previous 7 days	3.5 (1.7)	3.3 (1.6)	**3.6 (1.7)****	**3.3 (1.7)****	3.4 (1.7)
Number of households	**341**	**248**	**177**	**412**	**589**

Notes: (1) Standard deviations are presented in parentheses, (2) *** significantly different at 1%, ** significantly different at 5%, * significantly different at 10%

Table A 4. Characteristics of the farm

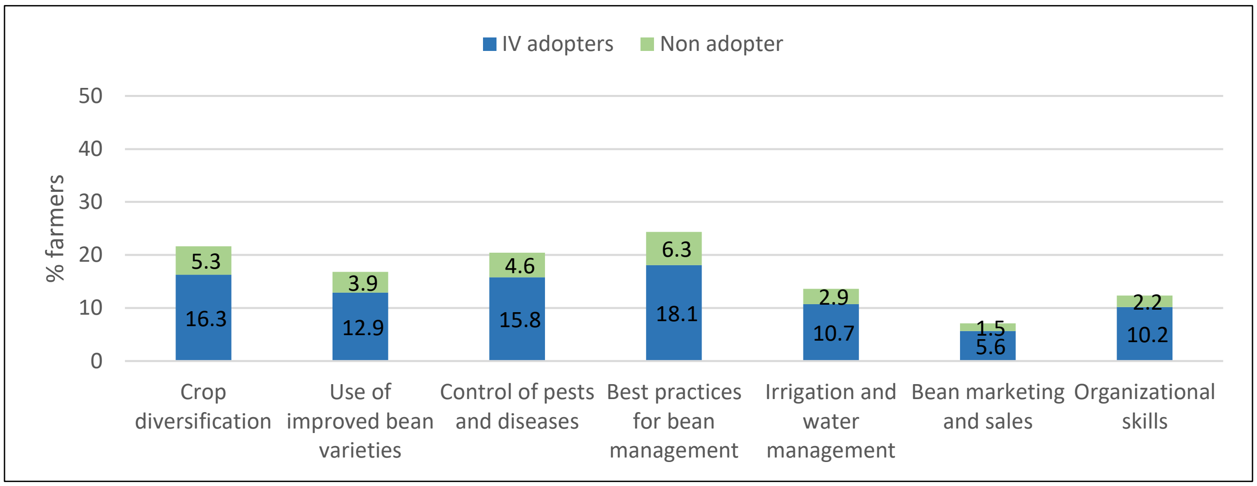
Characteristics of…	Region		Adoption		Total
	Dry corridor	Non-dry corridor	IV adopter	Non-adopter	
Farm:					
Total land (mz)	**8.5 (14.6)*** **	**23.5 (46.6)*** **	12.1 (16.1)	15.9 (37.9)	14.8 (33.0)
Land owned (mz)	**7.3 (14.7)*** **	**21.6 (43.4)*** **	10.9 (16.4)	14.3 (35.5)	13.3 (31.1)
Land with annual/temporary crops (mz)	2.0 (2.6)	2.3 (2.4)	2.1 (2.2)	2.2 (2.7)	2.2 (2.5)
Land with beans (mz)	**2.7 (3.1)*** **	**1.7 (1.9)*** **	**2.6 (2.6)* **	**2.2 (2.7)* **	2.3 (2.7)
Planting rate (lb/mz)	**79.0 (23.6)*** **	**85.1 (30.3)*** **	**77.7 (21.6)** **	**83.2 (28.6)** **	81.6 (26.7)
# varieties planted	**1.9 (1.3)*** **	**1.3 (0.7)*** **	1.8 (0.8)	1.6 (1.2)	1.7 (1.1)
# improved varieties planted	**0.6 (0.9)*** **	**0.4 (0.6)*** **	**1.6 (0.8)*** **	**0.0 (0.0)*** **	0.5 (0.9)
# traditional varieties planted	**1.4 (1.4)*** **	**0.9 (0.8)*** **	**0.2 (0.5)*** **	**1.6 (1.2)*** **	1.2 (1.2)
Adoption of improved bean varieties (IV):					
Households adopting at least one IV (%)	30.8 (0.5)	29.0 (0.5)	**100.0 (0.0)*** **	**0.0 (0.0)*** **	30.0 (45.9)
Area with IVs (%)	28.9 (0.4)	27.6 (0.4)	**94.2 (0.2)*** **	**0.0 (0.0)*** **	28.3 (0.4)
Bean varieties that are IVs (%)	28.7 (0.4)	27.2 (0.4)	**93.4 (0.2)*** **	**0.0 (0.0)*** **	28.1 (0.4)
Bean crop management:					
Bean varieties planted intercropped (%)	**11.7 (0.3)*** **	**0.0 (0.0)*** **	8.7 (0.3)	5.9 (0.2)	6.8 (0.2)
Number of observations	**341**	**248**	**177**	**412**	**589**
Improved bean varieties planted intercropped (%)	**14.8 (0.3)*** **	**0.0 (0.0)*** **	8.7 (0.6)	n.a.	8.7 (0.3)
Number of observations	**105**	**72**	**177**	**0**	**177**
Traditional bean varieties planted intercropped (%)	**10.5 (0.3)*** **	**0.0 (0.0)*** **	8.0 (0.3)	5.9 (0.2)	6.0 (0.2)
Number of observations	**251**	**186**	**25**	**412**	**437**
# bean plots managed:	**1.3 (0.7)*** **	**1.1 (0.6)*** **	**1.3 (0.6)*** **	**1.2 (0.6)*** **	1.2 (0.6)
Plots where applied fertilizer (%)	27.8 (0.2)	26.5 (0.2)	26.5 (0.2)	27.6 (0.2)	27.3 (0.2)
Plots where applied insecticide (%)	**22.8 (0.1)*** **	**18.5 (0.1)*** **	**19.6 (0.1)* **	**21.6 (0.1)* **	20.9 (0.1)
Plots where applied fungicide (%)	**8.2 (0.1)*** **	**3.8 (0.1)*** **	**8.5 (0.1)*** **	**5.4 (0.1)*** **	6.3 (0.1)
Plots where applied herbicide (%)	**40.8 (0.2)*** **	**50.7 (0.2)*** **	44.6 (0.2)	45.1 (0.2)	44.9 (0.2)
Households experiencing drought (% yes)	12.6 (0.3)	10.9 (0.3)	13.6 (0.3)	11.2 (0.3)	11.9 (0.3)
Number of households	**177**	**412**	**341**	**248**	**589**

Notes: (1) Standard deviations are presented in parentheses, (2) *** significantly different at 1%, ** significantly different at 5%, * significantly different at 10%

Table A 5. Use of bean harvest

Share of harvest used for:	Region		Adoption		Total
	Dry corridor	Non-dry corridor	IV adopters	Non-adopter	
Seed for next season	**9.1****	**7.1****	**7.0****	**8.8****	8.2
Own consumption	43.3	47.4	**38.9*****	**47.7*****	45.1
Sales	43.1	43.9	**51.1*****	**40.2*****	43.4
Other use	**4.5*****	**1.6*****	3.0	3.4	3.3
Number of households	**341**	**248**	**177**	**412**	**589**

Note: *** significantly different at 1%, ** significantly different at 5%, * significantly different at 10%



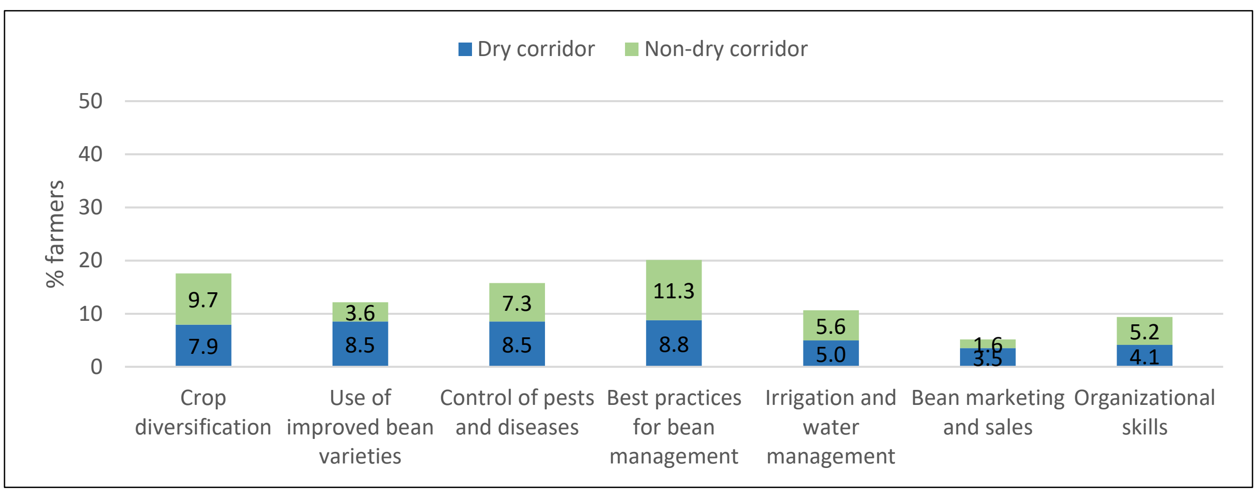


Figure A 1. Technical assistance received by IV adoption (top) and region (bottom)

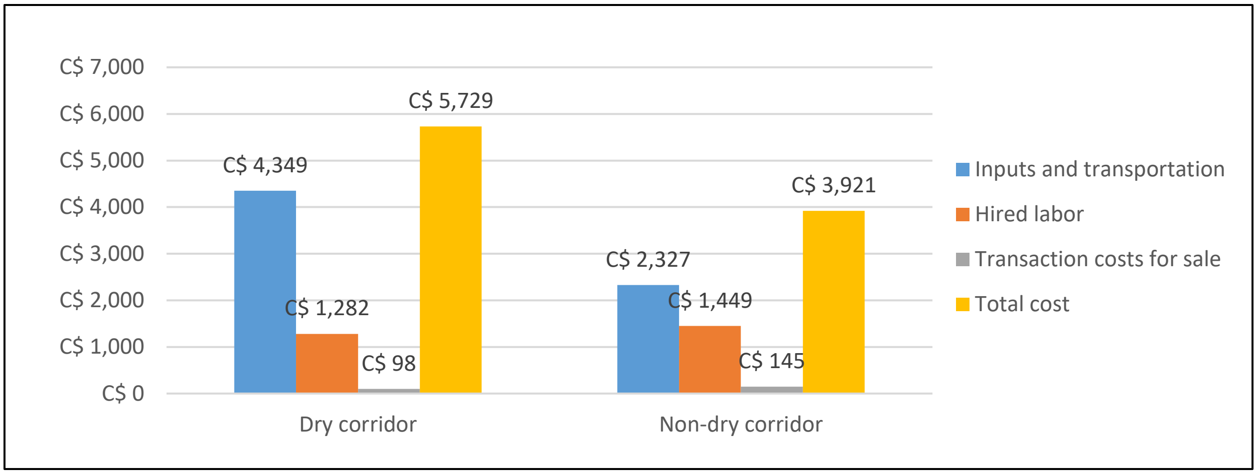


Figure A 2. Total production cost (Cordobas) in all seasons, by region

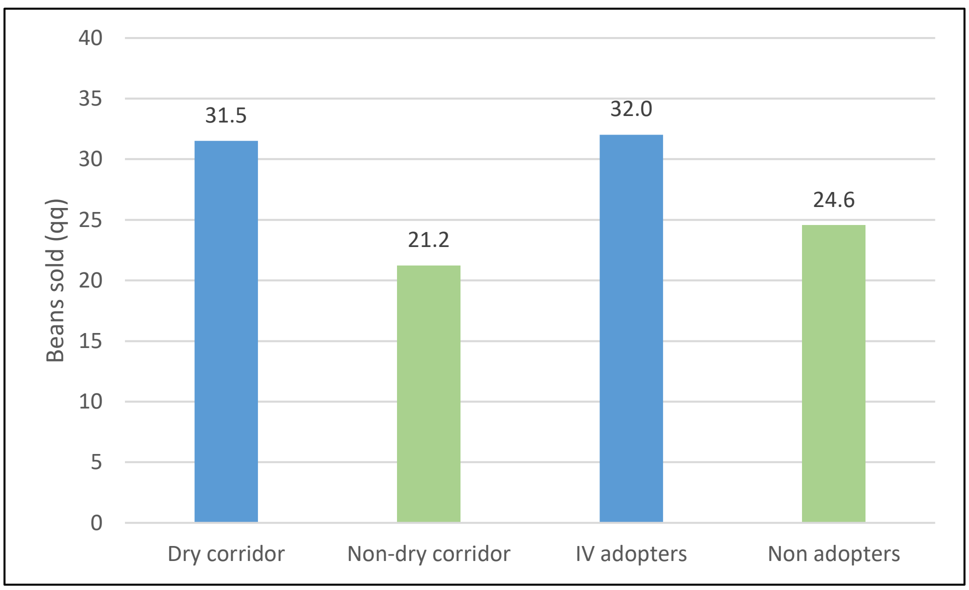


Figure A 3. Bean sales, by region and IV adoption