Sweet and Timely Insurance: The Role of Honey in Reducing Coffee Producer Food Insecurity Exposure in Mexico

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Abstract: Smallholder coffee producers face a combination of pre- and post-harvest risk factors that leaves them particularly vulnerable to food insecurity. A popular form of on-farm diversification is honey production through beekeeping, that has both nutritional and commercial value. This study investigates the role of honey production as means of food security management due to the heightened pollinating activity during the coffee flowering stage that follows the annual coffee harvest provides an additional non-contemporaneous source of income. Using primary data collected in coffee-producing regions of Chiapas, Mexico, I find that during the honey harvest months, which occurs during the early stage of the lean season, beekeeping coffee producers are less exposed to food insecurity over coffee producers who don't diversify into honey.

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1. Introduction

Among smallholder agricultural farms, coffee producers face a combination of risk factors that leaves them particularly vulnerable to food insecurity. Green coffee price volatility (price risk), along with climate and crop disease factors (harvest risk) affect the capacity of earning enough from the sale of their coffee harvest to meet their annual food consumption needs. In addition, most coffee harvests occur once per year, which the lack of an income-smoothing mechanism adds further budgeting constraints.

Food security among smallholder agricultural farms in low- and middle-income countries has unsurprisingly been a topic of interest within agricultural and development economics research, with much of the emphasis on mitigating quantity risk (Karlan et al., 2014; McIntosh et al., 2019) and price risk (Bellemare et al., 2013; Boyd & Bellemare, 2022). This research focuses on the fact that coffee producers are paid only once per year, at harvest time. A coffee producer may still experience months of food insecurity even in the absence of a crop or price shock, due to insufficient slack in the household budget to withstand unexpected expenses or budget management failure due to overexerted willpower (Mani et al., 2013). For smallholder producers that are just above the minimum requirement to meet their needs, the lack of an income smoothing mechanism makes maintaining food security an incredibly difficult task. To mitigate their exposure, coffee producers can diversify their income through on-farm and off-farm alternatives. On-farm diversification can be in the form of planting more food crops, or additional cash crops, while off-farm diversification options are to work on a neighbor's farm or to internally migrate (C. M. Bacon et al., 2014).

To further investigate the issue of food insecurity exposure for coffee producers, this study uses primary data collected from the Mexican state of Chiapas. Mexico is one of the 10 largest coffee exporters in the world, and the state of Chiapas is Mexico's primary coffee-producing state: accounting for 40% of all Mexican coffee exports (SIAP, 2022). Coffee is prominent in Chiapas due its high elevation regions with the Sierra Madre mountain range and the Central Highlands, but also because it is Mexico's southernmost state and borders Guatemala, another top 10 global exporter of coffee. However, Chiapas is also notable for another important statistic, it is also Mexico's poorest state, with 75.5% living in poverty, and 29% living in extreme poverty (CONEVAL, 2020). For indigenous communities where coffee is the primary source of income, these percentages are considerably higher, as over 90% of indigenous population in Chiapas live below the poverty line. (CONEVAL, 2019).

Within Chiapas, the largest indigenous population are the Mayan Tseltal community,[1] where the majority of live on agricultural communal lands called "ejidos", that was returned to indigenous possession through the passing of the 1917 Mexican Constitution. For those who live in the mountainous regions, coffee is one of the primary sources of income, as most coffee farms are able to sit under the shade of the forest canopy. But in recent years a new risk has creeped into the lives of coffee producers with a deadly fungus known as Coffee Leaf Rust (CLR)[2] has taking turns causing regional epidemics throughout various parts of the country ever since 2012 when coffee production dropped by 46% for the year (McCook, 2019). Food security is already a continuous concern, but in recent years the need for alternative income sources has significantly increased.

A subset of coffee producers are also beekeepers and harvest honey on their farm. Due to honey being a popular medicinal product in many cultures and being a pollinator of coffee trees, beekeeping has long been present on coffee farms. However, recent studies have found a relationship between honey production and lowered exposure to food insecurity (Anderzén et al., 2020). One of the possible reasons for this relationship that this research focuses on is the time in which honey is harvested. While bees may produce honey throughout most of the year in coffee-growing regions, there is generally one season where there is a surplus of honey for the coffee producer to extract, and generally occurs a couple of months after the annual coffee harvest (DaMatta et al., 2007; Martello et al., 2022). This occurrence is not coincidental, but rather there is link that draws coffee and honey together that takes place shortly after a coffee harvest has removed all the coffee cherries from the tree: the coffee flowering stage. While coffea arabica can self-pollinate, insect pollinators play an active role in fruit development on coffee trees, and can increase total coffee yields (Hipólito et al., 2018; Khan et al., 2007). When honeybees are located near a coffee farm, the most abundant local flowering plant will be coffee, and with a concentrated flowering stage results in a concentrated period of honey production. The coffee harvest season takes place over multiple months in a given country, but the farm-specific harvest timeline is typically within a single month. Since honey production is linked to and follows the coffee harvest timeline, this also implies that honey harvest timeline will be farm specific as well. Therefore, I hypothesize that

[1] Also commonly written as "Tzeltal" with a "z" instead of an "s".
[2] Scientific name: Hemileia vastatrix, also known as "La roya" in Spanish.

one of the primary benefits that honey provides is a source of income that is set to arrive when food insecurity exposure is rising.

This study explores plausible exogenous identification in the relationship between honey production and food insecurity, along with other coping mechanisms by focusing on two primary questions: (1) What is the relationship between time of year and food insecurity? (2) Does diversification into honey affect food insecurity exposure in a specific season?

During the summer of 2022, I collaborated with researchers from the University of Minnesota (Rev. Stephen Pitts & Chris M Boyd Ph.D.) and surveyed coffee producers from the Tseltal community (Figures 1 - 3), with logistical assistance provided by the organization Yomol A'tel. I find that of those surveyed, coffee producers who diversified into honey on their farm were less likely to experience food insecurity during the honey harvest season, and lower duration of months with food insecurity overall relative to those who were not honey producers.

2. Literature Review

2.1 Agriculture in Less-Developed Economies

Coffea Arabica, the most common plant used to produce coffee cherries, grows in high altitude mountainous regions between the Tropic of Cancer and the Tropic of Capricorn, where a narrow temperature range of 59 to 77 degrees Fahrenheit for optimal production (Thurston et al., 2013). The size and sensitivity to temperature variance has caused most coffee trees to be planted under a canopy of larger trees for much of coffee agricultural history. Furthermore, the criteria for agricultural land suitable for coffee production being mountainous forested land between the tropics means that most coffee farms rest on hillsides and not flat industrialized agricultural plots results in over 60% of all coffee produced comes from a farm size that is less than 5 hectares (Siles et al., 2022).[3]

The simplified process to go from cherry to the consumable product is the harvest, separating the seed from the fruit processing (green coffee), and roasting. Since most coffee is produced on smallholder farms, the total farm harvest is well below minimum levels of most export shipment orders, and thus require some form of intermediary to combine processed coffee from multiple farms within the region to fill a single export order. These

[3] Brazil is the exception, with most coffee comes from large, industrialized farms, and is the largest exporter of coffee in the world. Smallholder representation in coffee-producing countries outside of Brazil is considerably higher.

intermediaries tend to be a producer cooperative that individual farms are represented collectively, or through other local intermediaries. As a result, much of business transactions operates on an informal level, where incomplete and relational contracts play a larger role (Macchiavello & Morjaria, 2021). Coffee farms are family enterprises, and for most part every able-bodied member of the household is actively involved in the management and the decision-making process of the farm (Udry, 1996).

In remote agricultural regions, community and social networks play an integral part in the dynamics of coffee production, and regional culture affects the institutions that emerge within (North, 1991). It is through these cultural practices, and the practices that sustain over time that influence institutions that have been mostly ignored by conventional agricultural and economic theory in the past, due to its primarily internal validity and limited visibility of external validity (Corno et al., 2020; Jacoby & Mansuri, 2010; Nunn, 2007; Ostrom, 1990).

2.2 Production Risks

Risk in agricultural production is broken up into five broad categories: production, market, institutional, personal, and financial (Komarek et al., 2020), but when controlling for external factors beyond the scope of the business exchange, income risk primarily can come from two main avenues: production risk and price risk. For coffee producers in the western hemisphere, one of the most prominent sources of production risk is exposure to Coffee Leaf Rust (CLR). Climate change and monoculture production have been two prominent contributing factors in escalating its prevalence as warmer temperatures are making more mountainous regions more habitable for the fungus, and the lack of wind breaking shade trees increase the travel radius of the fungus spores to infect neighboring plants (Avelino et al., 2015).

To see if shade-grown farms perform better against Coffee Leaf Rust, a study observed if there was a divergence in outcomes during the event of an outbreak or other production shocks (C. M. Bacon et al., 2017). The study was conducted in Nicaragua, where coffee farmers suffered country-wide shocks in the years of: 1998, 2009, 2014 and Coffee Leaf Rust outbreak during the years of 2010 through 2014. They compared the outcomes of producers that were affiliated with either a Fair Trade organization that prioritized coffee sale prices, or a network of smaller organizations that emphasized diversification of agricultural crops. What they found was that average duration of seasonal hunger was lower for farms that derived at least half of their food consumption from subsistence production, and the probability of meeting that criteria lower in the members who were part of the Fair Trade organization.

Food insecurity is the product of insufficient funds when consumption is needed. This deficit can be due to low wages, but it can also occur if income is not timely. Since coffee harvests typically only occur on an annual or semi-annual basis, it exposes producers to the risk of running out of funds before the next harvest. A 2020 study found that coffee farmers in Chiapas, Mexico that were diversified in selling coffee, maize, and honey more than halved the reported time exposed to food insecurity, from 2.8 months to 1.3 months (Anderzén et al., 2020). When observing the timeline of income received, what stood out was coffee and maize harvests followed similar timelines, but sale from honey occurred during the rainy season, just as food insecurity rates started to escalate.

2.3 Price Risk

Much of current literature has focused on production risk, but given the historical volatility of coffee prices, price risk is just as important of a topic (C. Bacon, 2005). This issue is further amplified due to the overall shift in monoculture intensification in the coffee industry. Agnar Sandmo presents a model of how firms should operate in the presence of price uncertainty. Since coffee producers must make the allocation ahead of price confirmation, their investment into coffee production has the potential to result in a negative value if the final price is lower than the cost of production. Thus, utility conditional on the product of sale price and quantity, for a given probability of price. But there is another component that needs to be accounted for, which is the degree of risk tolerance that the coffee producer possesses. Since the producer can't control price in the future, they are functionally a price-taker with regards to the future, and thus the only component they can control is quantity produced. This results in quantity produced being determined by the probability of [(price * quantity) < (COGS)] and the level of risk tolerance they possess (Sandmo, 1971). Thus, the less risk tolerant the producer is, the less investment into production they will make. Sandmo further hypothesizes that risk tolerance affects allocation in the marginal change of risk probability as well using the Arrow-Pratt risk aversion functions (Arrow, 1965; Pratt, 1964).

However, there have been two recent studies on price risk that have challenged Sandmo's theoretical model. Marc Bellemare and a follow up study by Bellemare and Chris M. Boyd ran a lab-in-the-field studies of Peruvian potato farmers to observe how price risk affects production decisions (Bellemare et al., 2020; Boyd & Bellemare, 2022). What these studies conclude is that they break Sandmo's model of proportional response to volatility, and do not reduce production when introduced to price risk. In fact, the response is non-monotonic as more risk resulted in higher production. Moreover, when compulsory price insurance was enacted, variance between risk-free scenarios and risk-present with insurance were negligible.

2.4 Income Smoothing

Income smoothing as a function is a byproduct of inefficient credit systems. According to Jonathan Murdoch, a complete credit market creates smooth consumption, since any transitory income shocks are smoothed away by borrowing and saving. Any excess cash gets saved, and any deficit is borrowed out of. This can be tested by regressing household consumption on transitory income, and if the coefficient is close to zero, then the credit market is complete (Morduch, 1995). But if there is not a complete credit system presently available, then something external is required to produce an income smoothing effect for the individual. This means that consumption is now being caused by transitory income, and thus we need to determine the factors determining transitory income, which one of the biggest factors will be risk tolerance. Those with low risk tolerance will opt for income sources that reduce the variance in transitory income, and thus lower overall income potential (Murdoch, 1990).

Angus Deaton theorizes that in the presence of insufficient credit systems consumption is smoothed out by investing in buffer stocks that have the capacity to be converted into means of consumption at a later date (Deaton, 1991). Individuals seek to minimize variance in consumption, and while consumption is dependent on income, when it comes to time, individuals use varying levels of saving that don't require a formal credit system in order to smooth out consumption that is not dependent on the time of income (Deaton, 1991). This is the conscientious intent of the individual, but it is not always properly executed. Just as income may have a degree of uncertainty, so does consumption, or more accurately expenses. Individuals, and especially individuals with narrow savings margins are prone to being insufficiently prepared for large unexpected events, like medical emergencies (Mani et al., 2013).

2.5 Food Insecurity

The term "food security" is a common term used in development economics, and is quite visible in its absence, but defining its parameters is quite elusive. Amartya Sen observed how recent famines have been purely the product of institutions, not by the insufficient capacity to produce food (Sen, 1982). He then posited the Entitlement Approach to food security, which is the Endowment Set (resources an individual possesses), the Entitlement Set (all possible combinations of resources that could be had given the current endowment set), and the Endowment Mapping (the relationship between the sets). More recent frameworks have modified the terms to food security as the presence of three factors to a given individual: food availability, access to food, and the utilization of food. These factors are hierarchical in structure, since there first has to be food produced enough that is left available for the individual to consume (supply side), but also the individual needs to have the means to acquire (demand side), lastly the mechanisms have to be in place for the individual to conduct the exchange (efficiency & capacity) (Barrett, 2010).

2.6 Technology Adoption

For many coffee producers, coffee is the primary source of income, and honey becomes a secondary source of income that operates on a different seasonal schedule. To better understand what drives that kind of change, we can view this through the lens of technology adoption. Honey lends itself nicely to work in technology adoption since it has a direct financial impact, since previous studies have found it difficult to scale up adoption when the observed effect is something beyond financial profitability (Foster & Rosenzweig, 1995).

Just because there is an alternative path to increasing income, does not mean uptake will take place. Tavneet Suri and Christopher Udry's meta-analysis paper looks at various studies within African countries regarding technology adoption (Suri & Udry, 2022). What they conclude is that African countries deal with higher degrees of heterogeneity on critical issues that affect adoption rates, and the causal factors of adoption are themselves heterogeneous. In general, they've compiled a list of factors that have demonstrated strong influence on adoption rates in their studies: credit/liquidity constraints, insurance constraints, information constraints, transaction costs/infrastructure, and imperfect labor & land markets all independently affect technology adoption.

In my data, we visited 11 different communities in the Tseltal Mayan region, of which 5 of those communities had at least a 20% honey producer representation within our sample, and the other 6 communities were either below 10% representation or had no honey producers at all. This spread in vary levels of adoption connection to one of the classic models of technology adoption theory with Griliches' 1957 hybrid corn study (Griliches, 1957). Griliches noticed that while most states ended up with >90% adoption rate of hybrid corn, the path to getting there had varying shades of progression. They seemed to follow an S-shape curve, but where they would start varied, and the earlier it started, the sharper the adoption rate ended up being. Griliches used a logistic growth curve to model the adoption change of a hybrid seed that ended up being dominant for each specific state, and starting the time period for each state based on when that hybrid reached 10% adoption rate. What is found here is that adoption is dependent on the degree of change it can produce. States where the hybrid was highly profitable, uptake was faster. This corresponds to a cost-benefit risk analysis approach that corn farmers took. The more profitable the hybrid looked, the more were willing to take on the risk of adoption. While this study looked at whichever hybrid seed that ended up being dominant for a given state, this could be implemented in researching honey to see if different communities possess different attributes that make honey production more efficient and thus more profitable over others, and see if that is what determines which communities have adopted honey faster.

Another way to look at the heterogenous adoption paths of honey production is through the pathways of information. Using Conley & Udry's 2010 model of social learning's effect on adoption rates. To be able to measure learning, the authors designed "information neighborhoods" to identify how likely a geographically close neighbor was also a source of learning to a given individual. This was done by asking the respondent if they had gone to any of 7 randomly drawn village neighbors if they went to them for farming advice (Conley & Udry, 2010). What they found was that farmers were more likely to change input levels of fertilizer upon receiving news that the baseline strategy was poor. But less likely to change if there's bad news on the profitability of the alternative strategy. This insight is useful because coffee leaf rust can decimate an individual farm, thus if news comes out that a neighbor has lost a large portion of coffee trees, then uptake of diversifying in honey production may be higher. But this issue about experience with CLR also can be shown with models of technology adoption through revealed risk preferences, where a study of Chinese cotton farmers demonstrates that prospect theory does play a role in technology adoption, and lower risk tolerance was linked to low adoption rates (Liu, 2013). This approach would need to account for which way does previous exposure to CLR affect risk tolerance.

2.7 Biodiversity in Coffee

The primary focus of this study is on honey production, but that is just a subset of the sample population who are all coffee producers. With that in mind, it is important to understand the cumulative effect investment in honey production can have on coffee and the overall tropical ecosystem. As coffee became an export staple, and the influence of the Green Revolution has shifted coffee production to be focused on crop yield maximization, which has led to the transition to cutting down the tree canopy and squeezing the density of coffee tree planting as part of a monocrop plantation (Hernandez-Aguilera et al., 2019). While this has helped boost crop yields, we are now becoming more aware of the hidden benefits that these old growing methods had.

Deforestation has been one of the most discussed topics within the subject of climate change, and the Amazon Rainforest, the world's largest carbon sink, has been rapidly diminishing, along with earth's capacity to sequester carbon dioxide from the atmosphere. In 1996, El Salvador had already lost 98% of its original rainforest. However, 60% of the remaining rainforest were part of coffee farms that preserved the native forest canopy (Messer et al., 2000). There doesn't always have to be a tradeoff between agriculture and forestation, and with coffee, the means of production can actively contribute to reforestation, as in the case with El Salvador, where coffee production has become a protective shield that is holding back further deforestation.

Once we understand that a coffee farm does not have to be mutually exclusive from forested land, we can begin to measure the ecological impact that a sustainable farm can have. First and foremost, one of the criteria for forestation is native tree density, and with shade-grown coffee, the process of crop production is made so that coffee trees are planted next to larger trees and interspersed amongst other crops. With this shade canopy, coffee farms could capture approximately 56 tons of above ground carbon per hectare, and over 150 tons within the soil (Soto-Pinto et al., 2010). It is estimated that if 10% of sun-grown farms in 2010 had switched to even a low-density shade farm, over 1.5 billion tons of aboveground carbon could have been sequestered (Soto-Pinto et al., 2010). The canopy of large trees affects the soil in other ways too, in that the organic matter supplements organic nutrients, but also aids in water retention. The deep roots hold the soil together, which becomes especially important when adverse weather conditions occur. Coffee is grown along equatorial mountain ranges, which means some growing regions are vulnerable to hurricanes. When a hurricane strikes, monoculture sun-grown farms are more at risk of mudslides than shade-grown farms due to stronger tree root networks holding the soil together (Philpott et al., 2008).

Biodiversity in coffee production has an ecological impact as well, since the tree canopy helps preserve native bird species to the region. This canopy is not only a destination for birds, but it also provides a link to fragmented forest regions for migratory birds, thus preserving an insular ecosystem (Greenberg et al., 1997). Birds are a natural substitute to insecticides, as birds feed on many insects that are harmful to coffee production. One of the most prevalent pests is the Coffee Berry Borer (CBB), a small beetle that eats through the coffee seeds and kills fruit development, that comes at an estimated cost of $500 million USD in lost production annually (Jaramillo et al., 2011). It just so happens that tropical birds love to feast on CBBs, and it is estimated that a single bird reduced the level of crop loss by a range of 23 to 65 lb. of a given hectare (Hernandez-Aguilera et al., 2019). Birds are not the only species that migrate between forest fragments, pollinators like honey bees and butterflies are dependent on a shade canopy. Since coffee is a flowering plant, pollination is an integral part of fruit production. Thus when pollinators are preserved, it lowers the dependence on artificial fertilizers and has shown to increase yields by up to 20% (Jha et al., 2014).

2.8 Crop Intensification

In coffee production we're seeing that ever since the removal of the quota system for global coffee production, coffee intensification has been steadily increasing over time. In Latin America, 50% of coffee farms transitioned from traditional shade-grown status to either a sparsely-shaded or complete sun-grown monoculture between the years of 1970 and 1990. This trend is further demonstrated with data collected in 2010 on 19 coffee-producing countries that concluded that 41% of farmland was sun-grown monoculture, 24% remained traditional shade-grown, and 35% had a reduced sparsely-shaded polyculture (Jha et al., 2014).

Most coffee producers are smallholders and operate on very slim profit margins. As with commodities, coffee producers are for the most part price takers, and the only factor pertaining to their income potential that they can control is production quantities. There is an increasing incentive to rip out the canopy because not only does that free up space and nutrients for more income-generating cash crops, but also coffee cherry production grows faster and more abundantly with direct sun exposure.

In a 2019 study that evaluated the production difference between shade-grown and conventional sun-grown farms in Mexico, Colombia, and Peru. They found a weighted average coffee tree density of 4,104 per hectare for shade-grown farms. Meanwhile sun-grown farms can have a tree density of 7,500 per hectare or more. When comparing the net yield output between these two strategies, conventional sun-grown farms produced 2,972 pounds/ha, while shade-grown produced 2,286 pounds/ha. When accounting for variable costs, sun-grown coffee growers experience a net profit of $0.286/lb. a 13.5% increase in profit margin over shade-grown coffee (Hernandez-Aguilera et al., 2019).

3. Methodology and Data

3.1 Collection of primary and secondary data

To investigate the relationship between honey production and food security, this study provides primary data on 275 coffee producers, collected between the months of June and August 2022 in the central highland region within the Mexican state of Chiapas (Figure 1). This region is home to the Tseltal Mayan indigenous community, where most households are involved in agricultural production and the primary source of income comes from coffee. These farms are not privately owned, but are located on community-owned ejido lands. The village centers are located in remote mountainous regions that limit accessibility of visitation and coordination. Additionally, the majority of the coffee producers in this region speak the Tseltal Mayan dialect and low Spanish fluency. To mitigate these obstacles, we partnered with the locally-based organization, Yomol A'tel, along with its coffee and honey subsidiary cooperatives: Bats'il Maya & Chabtic,[4] for logistical management. Yomol A'tel has strong relationships within the Tseltal communities, and has Tseltal representation within the organization as well.

Prior to data collection, the research team visited the Chiapas city of Chilón, to with Yomol A'tel leadership, and Tseltal community representatives. We presented our research agenda, and received approval to visit the community centers and to conduct our research. The representatives then helped in broadcasting the survey schedule to allow coffee producers within the region to make necessary accommodations to be available to participate. Yomol A'tel facilitated the hiring of 10 enumerators who were fluent in both Spanish and Tseltal, in addition to managing travel logistics.

3.1.1 Survey Questions

Due to the survey involving financial questions, participants were first given a pre-survey evaluation consisting of three mathematical filter questions: (1) percentage calculation stated as "What is 40% of 100 MXN?", (2) simple arithmetic in context of coffee stated as "If you produce 17 bags of coffee and sell 9, how many bags do you still have?", and a probability

[4] Yomol A'tel serves as the parent organization to numerous commercial operations that serve the Tseltal Community. Bats'il Maya is the coffee head that consists of a coffee cooperative, microlending services, a coffee roastery located in Chilón, Chiapas, and the consumer brand Capeltic. Capeltic sells roasted coffee internationally and has coffee shop locations in Guadalajara, Mexico City, Puebla, and Chilón.

question "If there are 3 blue balls and 7 red balls in a bag, and you pick a ball at random. Is it more probable that it is red or blue?" This last question was visually demonstrated by the enumerator, where all 10 balls are displayed to the participant, and then placed into a small burlap bag. The enumerator then asks if they were to draw a ball from the bag, which color is more likely to be selected.[5] If the participant stated they were a coffee producer, and successfully answered 2 of the 3 math problems, they were permitted to take the survey.

The survey consisted of 40 questions, categorized into 5 sections: household demographics, income and food insecurity, farm characteristics, coffee production, and honey production[6]. Household demographics asked questions regarding to the participant's age, gender, family size, and dependents. Next participants were asked about how much farm-related income they earned in the past year, along with how much they earned from off-farm sources (e.g., working on a neighboring farm, or seasonal internal migration work). While income being present in mind, participants were then asked to select all months in the past year that there was not enough food to feed their family. Farm characteristics asked participants to select all the types of livestock and crops they have on their farm, along with the hectare size of their farm and a rank-order list of preferred change to their farm if they encountered a sudden boost in income. In the coffee production section, participants were asked how much coffee did they harvest in the past year, how much of their harvest did they sell to between the cooperative and local intermediaries (commonly referred to as "coyotes"), the highest and lowest prices they received, and what types of coffee varietals do they plant on their farm. 12 different coffee varietals were selected to choose from, half were arabica varieties that are susceptible to coffee leaf rust, while the other half consisted of arabica hybrid cultivars and Robusta varieties that are resistant to coffee leaf rust and other pests. Lastly, participants were asked if they also produce honey on their farm. If the participant stated that they were, they were then asked how much they harvested in the past year, and how much they sold their honey for. If participants stated they do not produce honey, then they were asked to rank on a scale of 1 to 10 their level of interest to start producing honey.

3.1.2 Data Collection

[5] Previous surveys have shown low literacy rates within survey regions, but discussions with Yomol A'tel and community leaders clarified that visual learning is very strong and probabilistic reasoning would be more accurately assessed if displayed visually.

[6] Survey questions and research methodology were given exception approval by independent review boards of both the University of San Francisco, and the University of Minnesota, in addition to Yomol A'tel leadership.

The enumerators were trained on how to operate tablet devices, where the survey question list was constructed using the open-source platform, Kobo Toolbox.[7] The research team consisted of 2 doctoral students, 1 graduate student, 10 enumerators, and 3 Yomol A'tel project leaders. This study was conducted in 11 village centers within the municipalities of Chilón, Ocosingo, Sitalá, Pantelho, and Yajalón, where a total of 275 coffee producers participated in the survey (Figure 2). Of those who participated, 128 (47% of sample population) were coffee cooperative members, 54 (20% of sample population) were honey producers, and 21 of the honey producers were also in the honey cooperative (55% of cooperative members).

Yomol A'tel's coffee cooperative, Bats'il Maya, provided extensive data on their 741 cooperative members, along with transaction receipts of coffee graded and purchased from cooperative members from the years of 2013 through 2019. Chabtic is the latest cooperative within Yomol A'tel, with 38 honey producing cooperative members. We were given data on membership and 2022 transaction receipts. In addition, prior household surveys were conducted (Pitts, 2019) was also used to match participants in this study.

3.2 Household Survey

Without controlling selection to participate, this study achieved balanced gender representation with 138 males, and 137 females. The average age in this study was 43.4 years (15.6 std. dev.) The widespread in age is due to non-head-of-household and head-of-household members alike participating in the survey,[8] we did not exclude non-head-of-household representatives from participating due to farm labor and management is shared by multiple members within the family. For education, 75% of sample reported only receiving primary education, while only 29 (10.5%) reported finishing high school. While the education level is low and 74% reported to be able to read and write, 99% of respondents passed basic math problems of calculating sales percentages and inventory subtraction. The only problem met with difficulty was a math problem based on probability, which 74% respondents answered correctly. Family size averaged was 6.8 members (3.1 std. dev.), with 2.4 members on average being either under the age of 12, or above 65 (Table 1).

[7] The primary language used is the Mayan dialect of Tseltal, which is not a written language. Therefore, all scripts and answers were recorded in Spanish, and cannot control for variation in enumerator translation of responses that were stated in Tseltal.

[8] Only one member per household was permitted to take the survey.

3.2.1 Farm Characteristics

Participants reported on average having 3.65 hectares of farmland, with 81% stating over 70% of their farmland's primary use was for coffee production. Since coffee is typically grown under the shade canopy of larger trees, the land allocated to coffee does not prohibit the presence of other crops in that area. In addition to growing coffee, participants reported on average to be growing 9 of the 15 possible types of crops on their farm.

On average, participants reported having 2.4 (1.3 std. dev.) types of coffee trees on their farm, and 34% (.31 std. dev.) of those types were CLR-resistant hybrids (Table 1). None of the household demographics displayed any significant relationship to the percentage of CLR-resistant hybrids on a given farm, nor the size of the farm or quantity of coffee harvested.[9] The most commonly-listed cultivar in the survey was Garnica, which is a cross between the Caturra and Novo Mundo varietals. Garnica is known to produce quality flavors, but due to Caturra and Novo Mundo are both susceptible to CLR, Garnica is also highly susceptible (Couttolenc-Brenis et al., 2020). The second most common cultivar was Oro Azteca, which is a CLR-resistant hybrid. On the other extreme, the least common was Robusta. Regardless of the threat to a CLR outbreak, participants have shown a preference to adopting arabica hybrid cultivars instead of defaulting to the safest alternative with the low-grade Robusta variety (Table 3).

In the post-harvest stages of coffee production, coffee cherries need to be depulped to remove the seeds from the rest of the fruit,[10] then a drying stage breaks off the protective parchment shell to arrive at the exportable product of green coffee. Coffee producers can sell their coffee to an intermediary at any point in this process, but it is most common to sell at the parchment stage or the green coffee stage. On average, coffee producers in sample harvested 371kg. of green coffee on average. In the process of selling parchment and green coffee, sales are measured in quintals, which are 60kg. bags. Thus, the average harvest yielded 6 quintals (Table 1).

3.2.2 Honey Producers vs. Non-Honey Producers

When comparing honey producers to non-honey producers, there were no significant differences in mean values for age, farm acreage, education level, and income. However, honey

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[9] The lone exception being the total number of varieties present was positively correlated with the percentage of CLR-resistant hybrids being listed. Since the survey does not measure the tree quantity of trees of each variety, this relationship is assumed to be small scale experimentation of these new hybrids.

[10] This is most commonly done through the method called "washed process" which involves mechanical depulping, and water tank fermentation to separate mucilage.

producers were found to be 9% less likely to be female, 1 additional family member on average, and almost twice as likely to be a cooperative member over non-honey producers. In alignment with literature regarding biodiversity, honey producers had 12% more coffee varietals, and slightly more types of food crops with 3% higher average value. We also find higher yield and yield density on honey-producing farms with a full additional quintal's worth of coffee harvested over non-honey producers. For total duration for food insecurity, honey producers reported 10% less duration with 1.67 months of food insecurity (Table 2). We find honey producers within 8 of the 11 survey regions, and the majority of them are concentrated within 5 regions (Figure 12); in these regions, at least 20% of coffee producers produce honey as well.

3.3 Seasonality Timeline

Using Yomol A'tel internal records from the years 2013 – 2019, parchment coffee was sold between the months of December through April.[11] Meanwhile, Chabtic sales data from 2021 – 2022 found honey was collected during the months of March through June.[12] There is overlap between honey harvest and coffee harvest timeline, and therefore we use the months where honey sale concentrations were higher than coffee sales as our months of interest to define as the honey season. The months that satisfy this criterion are April, May, and June, and these three months account for 83% of all honey sales (Figure 4).

3.3.1 Food Insecurity Timeline

Food insecurity was found in all 12 months within the survey, 94% of all reported food insecurity occurred during the months of April through September.[13] The most frequently reported month of experiencing food insecurity was July with 47% of sample population experienced food insecurity in that month, followed by the months of August and June where 121 and 88 of sample population reporting to have experienced food insecurity respectively (Figure 5). These high rates of reported food insecurity confirm that food insecurity is not an isolated issue but rather is an ongoing risk that the whole community is exposed to. While 49 individuals reported no months of food insecurity in the past year, 22 reported going least a third of the year without adequate food supplies. To define the period of highest risk of experiencing food insecurity, or what is commonly referred to as the "Lean

[11] Outliers of 2% occurred in May, and 1% occurred in November.
[12] 94% of total honey sales occurred between March and June. Outliers of 1% in January, 2% in February, and 3% in July.
[13] Outliers of 2% in January, 1% in February, and 3% in March.

Season", we set a continuous 25% incidence rate cutoff, which captures the successive months between June and August as the only months that more than 25% of sample population experienced food insecurity. As for the low occurrence of reported food insecurity during the months of can be explained as preorder sales of coffee to intermediary processors and cooperatives (Macchiavello & Morjaria, 2021).

4. Empirical Strategy

4.1 Monthly Variation

By having responses of which months have the respondents experienced food insecurity in the past year, the survey was constructed into panel data form to produce 3,300 observations of the sample population. To identify variation in food insecurity by month I use the following specifications:

$$y_{i,m} = \sum_{m=2}^{12} \delta_{m1}\text{month}_m + \epsilon_{i,m} \tag{1}$$

$$y_{i,m} = \sum_{m=2}^{12} \delta_{m2}\text{month}_m + \alpha_i + \epsilon_{i,m} \tag{2}$$

$$y_{i,m} = \sum_{m=2}^{12} \delta_{m3}\text{month}_m + \beta X_i + \epsilon_{i,m} \tag{3}$$

(1) Baseline estimation of food insecurity in each individual month, y is an indicator variable that is true if an individual reported experiencing food insecurity in the observed month. (2) baseline with individual fixed effects. (3) baseline with demographic controls of age, gender, education level[14], family size, number of dependents, cooperative membership, and years of coffee producing experience.

4.2 Instrumented Difference-In-Differences Approach

To evaluate the effect of honey production has on food insecurity exposure, I will be focusing on the seasonality effect between honey production and food insecurity. As displayed in Figure 1, Coffee occurs in a concentrated period of the year, which creates a link to the honey harvest following immediately afterwards due to abundance of coffee tree flowering

[14] Categorical variable where 1 is for primary education, 2 is secondary education, and 3 is high school graduate.

that is required for the next coffee harvest cycle to begin. As coffee sales begin to drop, the instance of food insecurity starts to creep up.

I will be using an instrumented difference-in-differences estimation approach (Duflo, 2001), to measure the effect of being a honey producer has on the probability of being food insecure during the honey harvest season. This approach uses a linear probability model, and considering the use of panel data can have correlations with unobservables, I will also use clustered standard errors at the individual level with individual fixed effects on the following specification:

$$y_{i,m} = \alpha_0 + \beta T_i + \gamma S[m \in \{4,5,6\}] + \theta T_i S[m \in \{4,5,6\}] + \tau_i + \varepsilon_{i,m} \quad (4)$$

The outcome of interest y is a dummy variable that indicates the presence of food insecurity reported in a given month. T is the treatment dummy variable of being a honey producer or not, while S is a season dummy variable to indicate if a given month observed is between the months of April through June. Lastly the interaction between treatment and season is a dummy variable that is true for observations where the individual is honey producers and in either the months of April, May, or June. This specification will produce the probability of being food insecure for both treatment and control participants during the months of July through March and compare the distance between treatment's probability of food insecure in the honey harvest season to the expected probability treatment would have if the relationship to control stayed constant.

4.3 Instrumental Variable

Since the treatment variable of being a honey producer is an element that is determined by the individual, it is possible that the adoption of honey production could be correlated with unobserved characteristics that affect food insecurity and produce bias in the estimation of the honey production's effect on food insecurity. With this endogeneity concern, an instrumental variable will be included to the previous specification. The instrumented variable is the percentage share of the individual's neighbors in their community who are honey producers (Sellare et al., 2020).

$$Z_{ir} = \frac{\sum_{j=1,j\neq i}^{n_r} T_{jr} - T_{ir}}{n_r - 1} \quad (5)$$

This is calculated by taking the total number honey producers in the survey region (11 total regions in study) divided by total number of individuals in the survey region, minus the observed individual. If the observed individual is themselves a honey producer, then the total of honey producers in region will be reduced by 1. I then take the fitted values of $\hat{T}$ in the first stage OLS to run the instrumented regression with clustered standard errors and individual fixed effects:

OLS: $y_{i,m} = \alpha_0 + \beta_{OLS}T_i + \gamma_{OLS}S[m \in \{4,5,6\}] + \theta_{OLS}T_iS[m \in \{4,5,6\}] + \tau_i + \varepsilon_{i,m}$ (6)

First Stage Fitted Values: $T = \alpha + \beta Z + \varepsilon \quad \rightarrow \quad \hat{T} = \hat{\alpha} + \hat{\beta} Z + \varepsilon$ (7)

IV: $y_{i,m} = \alpha_0 + \beta_{IV}\hat{T}_i + \gamma_{IV}S[m \in \{4,5,6\}] + \theta_{IV}\hat{T}_iS[m \in \{4,5,6\}] + \tau_i + \varepsilon_{i,m}$ (8)

4.3.1 Case for Instrumental Variable

While being a honey producer may be endogenous, however living in a region with honey producers is plausibly exogenous. Tseltal communities are located on communal ejido lands that have been returned to indigenous possession with the passing of the 1917 Mexican Constitution Article 27, which granted residents communal land tenure rights for agricultural purposes in perpetuity (Jones & Ward, 1998). However, this land was not to be privately owned, and thus the ejido could not be bought, sold, mortgaged, or divided into individual private parcels either. However, in 1992 Article 27 was revised to allow for limited privatization and sale of ejido land, but with the requirement of all ejidatarios (ejido residents) to approve of a sale, sales are rare mobility is severely limited in the Chiapas highlands. Therefore, for most coffee producers in this study, where one currently lives is primarily due to family inheritance and not due to market forces, and as such, an individual cannot control where they live and how many of their neighbors have started beekeeping (Figure 3).

If the percentage of one's neighbors who are honey producers is exogenous, this supports the relevance condition of this instrument in that to take up beekeeping in these remote regions, one must first learn about this method and borrow a starter beehive from a neighboring honey producer. In these remote ejido lands, cellular communication is sparce, with 2020 census data on villages where study surveys were located, 16% of residents reported to have access to a cellular phone (Pueblos America, 2020). Travel to the nearest city was on average 22km, but this is geographic distance and not driving distance, which considering these villages are up along the mountain range, driving can easily exceed 2 hours by automobile. But that estimate is dependent on automobile accessibility, which car ownership is uncommon. Of the 11 survey regions, only 3 have census data reporting any car ownership, with the highest ownership density was 5.26% of residents of the village San Jose Veracruz had an automobile. Public transportation does not operate in the Chiapas Highlands, and so the primary means of transportation is through a taxi network. As a result, access to information and resources is severely limited. And as such, local communities serve an important role in shared learning and resources. For most current honey producers, they borrowed a beehive and learned how to manage it while they saved up to purchase additional beehives in the future.

To satisfy the exclusion restriction requirements, the share of neighboring honey producers only affects food insecurity through the channel of honey production. This requirement could be violated if a characteristic of the instrument affects food insecurity directly, for instance if neighboring honey producers give excess food to non-honey producers during the honey harvest season. Table 4 compares the difference in means between 5 regions with high regional honey producer density, and 6 with low regional density (Figure 7). To be categorized as a "honey region" a given survey region must have at least 20% honey producer representation (Figures 8 & 11). Based on the results found in Table 4, the regional characteristics between honey regions and non-honey regions do not appear to large enough to demonstrate a material spillover effect where neighboring honey producers are affecting the exposure to food insecurity of their neighbors. Finally, by controlling for the outcomes of being a honey producer, the instrument remains unbiased to treatment effects when evaluating the impact of the honey season.

5. Results

5.1 Honey Producers and Food Insecurity

When running models 1-3 as displayed in Table 5, the relationship between month and food insecurity remains significant at a 0.1% level for the months of April through September throughout all three specifications of the baseline, fixed effects, and demographic controls.[15] October through December were significant at the 2% level. As displayed in Figure 4, the months of March through September are positively correlated with food insecurity, while the months of October through February are negatively correlated.

5.2 Honey Producers and Food Insecurity

In the regressions of food insecurity, food insecurity is the dependent variable, and a negative coefficient indicates that a true (=1) value of a given independent variable is negatively correlated with the probability of being food insecure. With the difference-in-differences approach (model 4) of being a honey producer in the honey harvest season, we find a negative point estimate of -0.0719 for food insecurity in all three specifications of the baseline, with individual fixed effects, and with demographic controls as seen in models 1-3.

[15] Since the survey data was reshaped into a 12-month panel data set, introducing controls into the regression does not affect the point estimates due to the controls not being time-varying variables.

Figure 6 displays the parallel trends assumption of these findings. For the months outside of the honey season (July – March), the probability of experiencing food insecurity was 13.4% for honey producers, and 13.1% for non-honey producers. For the months of April – June, food insecurity increases by 2% for a total of 15.4% for honey producers, meanwhile non-honey producers' exposure to food insecurity raises by 9.2% to a total of 22.3%. The parallel trends assumption would project the expected level of food insecurity for honey producers during April – June to be 22.6%, when the realized outcome was 7.2% below what was projected. This can also be stated as being a honey producer lowered the season effect on food insecurity by 78%. However, with clustered standard errors, these results are just past the 10% significance level under this set of specification.

5.2.1 Instrumental Variable Approach

Table 7 displays models 6-8, where column (1) displays the OLS specification with individual fixed effects, like in Table 6. Column (2) displays the first stage on the instrumental variable of share of region being honey producers on honey producers is 0.90 and is significant at a 0.01% level and an F statistic of 89.50 indicates it to be a strong instrument. When using an instrumented difference-in-differences approach (model 8, displayed column (3)), being a honey producer during the honey harvest season has a coefficient of -0.188, and is significant at a 2% level. The OLS and the IV stages agree with the direction that the relationship between honey producers and food insecurity has, in that both indicate a negative relationship. However, the IV estimates that the effect of being a honey producer is actually larger than the season effect, in that during the months of April – June, honey producers' exposure to food insecurity lowers by 7.3%, meanwhile non-honey producers experience an increased exposure of 11.5%.

5.3 Robustness Checks

The null hypothesis is that the difference in coefficients in a 2SLS specification between OLS and IV is not systematic, and that the treatment variable of honey producer is not biased. To test this hypothesis, the Hausman Test was conducted on the OLS and IV regressions shown in Table 7 results in a prob > chi2 = 0.2145. Since the p-value does not cross below 0.05, we fail to reject the null hypothesis that there are not systematic differences between OLS and IV.

5.3.1 Lean Season.

If income smoothing is a contributing factor to seasonal hunger, then the effect of being a honey producer should diminish in the months following the honey harvest season. The lean season begins in the final month of the honey season and extends out through the month of August. To see if the effect of honey extends into the lean season, I rerun models 6 & 8, but replacing the honey season for the lean season (June – August). Table 8 shows that as expected, the effect of being in the lean season significantly increases food insecurity exposure by 34.8% (1) – 36.3% (2) over the constant probability of 6.4%. Being a honey producer has very little effect in OLS (-0.6%) and moderately in IV (-8.3%), but neither are statistically significant.

5.3.2 Substitution Between Income Sources

In the remote mountains of the Chiapas Highlands, Tseltal families that live on agricultural ejidos have limited options to generate income. We distinguish two types of in-farm income activities (coffee and honey sales) and two types of off-farm activities (day labor and internal migration). Figures 9-10 displays the overall components of income and correlation among types of off-farm income for honey producers and non-honey producers. Approximately two-thirds of both groups do not receive off-farm income. Producers appear to be substituting between intensifying coffee production and diversifying into honey production on farm and between day labor and internal migration off-farm.

6. Summary

This thesis examines the relationship between coffee producers who diversified into beekeeping, and their exposure to food insecurity during the honey harvest season. This was done using an instrumented difference-in-difference approach that controls for the individual characteristics of the subject, along with their exposure to food insecurity in the previous 9 months, and compares the difference in outcomes during the honey harvest season when compared to coffee producers who did not take up beekeeping.

What this study finds is a negative relationship between honey seasonality and food insecurity; when controlling for demographic characteristics, individual fixed effects, and endogeneity of take-up, producing honey is negatively associated with food insecurity exposure during the honey harvest season. In addition, the difference in means in total food insecurity duration is lower for honey producers, which aligns with previous studies in Chiapas, Mexico (Anderzén et al., 2020).

This paper contributes to the literature on food insecurity among agricultural producers by exploring the causal mechanisms behind the relationship between honey production and food insecurity and the adoption of honey production. Previous literature has described the associations between food insecurity, honey production, and other coping strategies descriptively but not causally. The findings in this paper can inform future research and public policy to improve smallholder producers' food security.

Future work can enhance the foundation set in this study by conducting a longitudinal study of the Tseltal community, with annual surveys on food insecurity timeline, and coffee harvest yields. Most importantly, either observing future coffee producers who take-up learning how to be a beekeeper, or by facilitating a controlled environment for who is given the incentive to start beekeeping will enhance the validity of the parallel trends assumption and provide deeper understanding of honey production affects the economic wellbeing of Tseltal coffee producers.

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Appendix

Table 1. Summary Statistics: Regional Demographic Mean Values

Demographics	Population	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Age	**43.43**	47.25	39.88	37.63	39.04	48.04	43.71	40.62	45.32	51.00	49.43	42.71
Female	**0.50**	0.25	0.44	0.63	0.52	0.50	0.38	0.42	0.52	0.30	0.57	0.63
Edu Level (1 - 3)	**1.35**	1.50	1.44	1.50	1.32	1.23	1.24	1.08	1.44	1.43	1.17	1.49
Family Size	**6.81**	6.38	6.12	6.42	8.48	5.77	7.90	10.15	5.60	5.22	5.83	6.86
Dependents	**2.35**	0.75	2.76	2.29	2.32	1.88	4.00	3.65	2.28	1.74	2.17	1.46
Cooperative Member	**0.47**	0.75	0.48	0.11	0.48	0.85	0.57	0.77	0.48	0.78	0.39	0.03
Years of Coffee Experience	**17.33**	25.50	18.24	11.21	14.48	20.65	15.90	13.69	23.68	22.09	18.48	16.20
Farm Characteristics												
Farm Hectares	**3.65**	4.25	3.12	2.95	3.64	3.50	5.95	3.58	2.60	4.13	3.48	3.97
Total Coffee Varietals	**2.39**	2.38	2.72	2.34	2.56	2.27	2.24	2.69	2.48	1.96	2.78	2.03
Total Types of Crops	**9.16**	9.50	9.04	9.76	9.72	9.31	8.62	9.04	8.44	9.04	10.13	8.40
Resistant Varietal Percentage	**0.34**	0.41	0.26	0.31	0.32	0.57	0.32	0.35	0.37	0.24	0.29	0.34
Coffee Harvest (kg)	**371**	129	304	314	351	436	370	594	210	359	244	541
Outcome Variables												
Pre-Honey Income (MXN)	**17028**	8143	17767	16508	14581	22010	21701	22714	11814	16706	13393	16436
Post-Honey Income (MXN)	**19798**	8143	18370	16981	17726	23756	21701	31877	12034	31156	14638	16436
Months of Food Insecurity	**1.81**	1.62	1.68	1.74	1.64	2.00	1.33	1.19	2.16	2.04	1.96	2.26
Percentage of Honey Producers in Region	**0.20**	0.00	0.08	0.03	0.28	0.35	0.00	0.65	0.04	0.52	0.22	0.00
N	275	8	25	38	25	26	21	26	25	23	23	35

Table 2. Summary Statistics: Honey Producers vs. Non-Honey Producers

	(1) Honey Producers		(2) Non-Honey		(3) Difference	
Demographics	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**T-Statistic**
Age	**43.39**	15.18	**43.43**	15.74	**- 0.05**	(-0.07)
Female	**0.43**	0.50	**0.52**	0.50	**- 0.09*****	(-4.14)
Edu Level (1 - 3)	**1.32**	0.63	**1.36**	0.67	**- 0.05**	(-1.68)
Family Size	**7.63**	3.79	**6.62**	2.91	**1.01*****	(6.37)
Dependents	**2.85**	3.15	**2.23**	2.23	**0.63*****	(4.77)
Cooperative Member	**0.70**	0.46	**0.41**	0.49	**0.30*****	(14.58)
Years of Coffee Experience	**18.85**	15.04	**16.96**	12.90	**1.89****	(2.94)
Farm Characteristics						
Farm Hectares	**3.76**	2.42	**3.62**	3.62	**0.14**	(1.18)
Total Coffee Varietals	**2.61**	1.31	**2.34**	1.34	**0.27*****	(4.71)
Total Types of Crops	**9.39**	2.52	**9.11**	2.62	**0.28***	(2.52)
Coffee Harvest (kg)	**421.72**	466.01	**358.70**	308.16	**63.03****	(3.27)
Outcome Variables						
Pre-Honey Income (MXN)	**17,913**	15,202	**16,811**	15,320	**1,101**	(1.65)
Post-Honey Income (MXN)	**32,020**	21,254	**16,811**	15,320	**15,208*****	(17.16)
Months of Food Insecurity	**1.67**	1.33	**1.85**	1.25	**- 0.18****	(-3.11)
N	**54**		**221**		**275**	

Table 3. Coffee Varieties. Honey Producers vs. Non-Honey Producers

	(1) Honey Producers		(2) Non-Honey Producers		(3) Difference	
Varietals	Mean	Std. Dev.	Mean	Std. Dev.	Mean	T-Statistic
Susceptible to CLR						
Garnica	**0.83**	0.37	**0.77**	0.42	**0.06*** **	(3.82)
Bourbon	**0.35**	0.48	**0.30**	0.46	**0.05***	(2.56)
Caturra	**0.28**	0.45	**0.22**	0.42	**0.06****	(2.89)
Mundo Novo	**0.09**	0.29	**0.09**	0.29	**0.00**	(0.17)
Typica	**0.06**	0.23	**0.04**	0.19	**0.02***	(1.99)
Maragogype	**0.02**	0.13	**0.04**	0.20	**-0.02*****	(-3.39)
Pacamara	**0.02**	0.13	**0.03**	0.18	**-0.01***	(-2.09)
Resistant to CLR						
Oro Azteca	**0.52**	0.50	**0.39**	0.49	**0.13*****	(5.93)
Catimor	**0.24**	0.43	**0.29**	0.45	**-0.04***	(-2.34)
Gesha	**0.19**	0.39	**0.11**	0.31	**0.08*****	(4.66)
Tabi	**0.00**	0.00	**0.05**	0.23	**-0.05*****	(-12.34)
Robusta	**0.02**	0.13	**0.01**	0.12	**0.00**	(0.86)
Resistant vs. Susceptible						
Total Resistant Varietals	**0.96**	0.75	**0.85**	0.80	**0.11*****	(3.39)
Total Susceptible Varietals	**1.65**	0.97	**1.49**	0.96	**0.16*****	(3.77)
Resistant Percentage	**0.37**	0.30	**0.33**	0.31	**0.04****	(2.87)
N	**54**		**221**		**275**	

Table 4. Summary Statistics: Honey Regions vs. Non-Honey Regions

	(1) Honey Region		(2) Non-Honey Region		(3) Difference	
Demographics	Mean	Std. Dev.	Mean	Std. Dev.	Mean	T-Statistic
Age	**45.46**	15.81	**41.78**	15.29	**3.67*****	(6.73)
Female	**0.46**	0.50	**0.53**	0.50	**-0.06*****	(-3.60)
Edu Level (1 - 3)	**1.24**	0.58	**1.44**	0.71	**-0.20*****	(-8.77)
Family Size	**7.15**	3.53	**6.54**	2.72	**0.61*****	(5.50)
Dependents	**2.37**	2.49	**2.33**	2.41	**0.05**	(0.52)
Cooperative Member	**0.66**	0.47	**0.31**	0.46	**0.35*****	(21.27)
Years of Coffee Experience	**17.79**	13.34	**16.97**	13.37	**0.82**	(1.76)
Farm Characteristics						
Farm Hectares	**3.66**	2.64	**3.64**	3.94	**0.02**	(0.18)
Total Coffee Varietals	**2.46**	1.16	**2.34**	1.46	**0.11***	(2.48)
Total Types of Crops	**9.44**	2.29	**8.94**	2.82	**0.50*****	(5.61)
Coffee Harvest (kg)	**402.33**	360.97	**345.78**	330.83	**56.56*****	(4.64)
Outcome Variables						
Pre-Honey Income (MXN)	**18046.38**	15485.06	**16204.05**	15105.46	**1842.34*****	(3.44)
Post-Honey Income (MXN)	**23926.07**	19645.26	**16457.93**	15182.86	**7468.15*****	(11.99)
Months of Food Insecurity	**1.76**	1.39	**1.86**	1.16	**-0.10***	(-2.19)
Percentage of Honey Producers in Region	**0.41**	0.16	**0.03**	0.03	**0.38*****	(89.24)
N	**123**		**152**		**275**	

Figure 1. Chiapas Map

Figure 2. Survey Regions

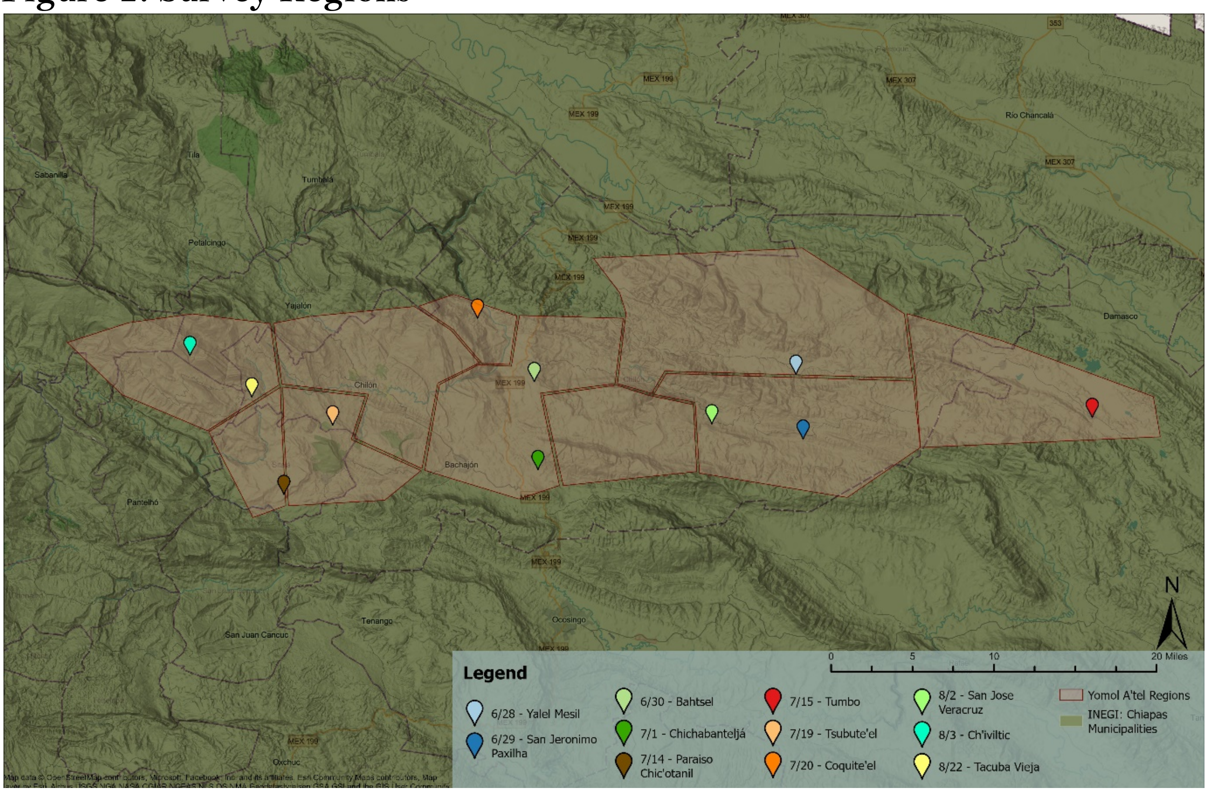


Figure 3. Ejido Land Parameters

Figure 4.

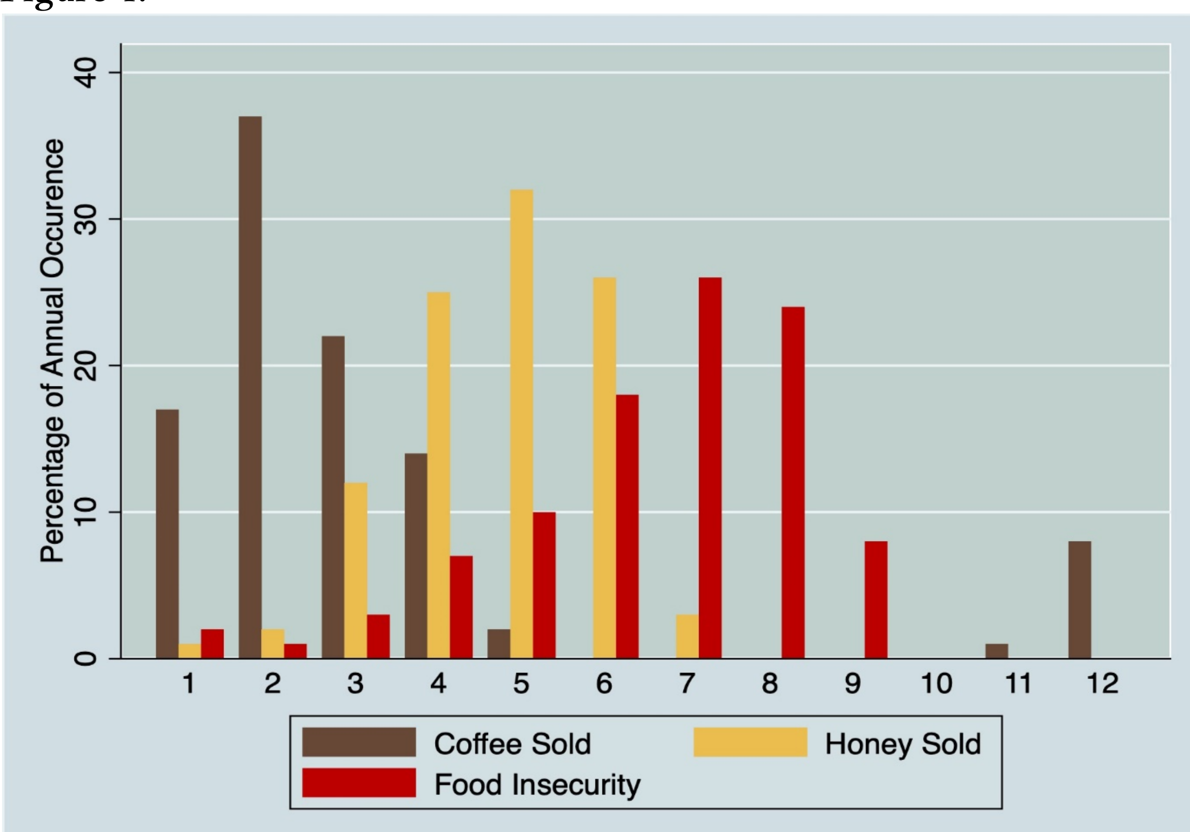


Figure 5.

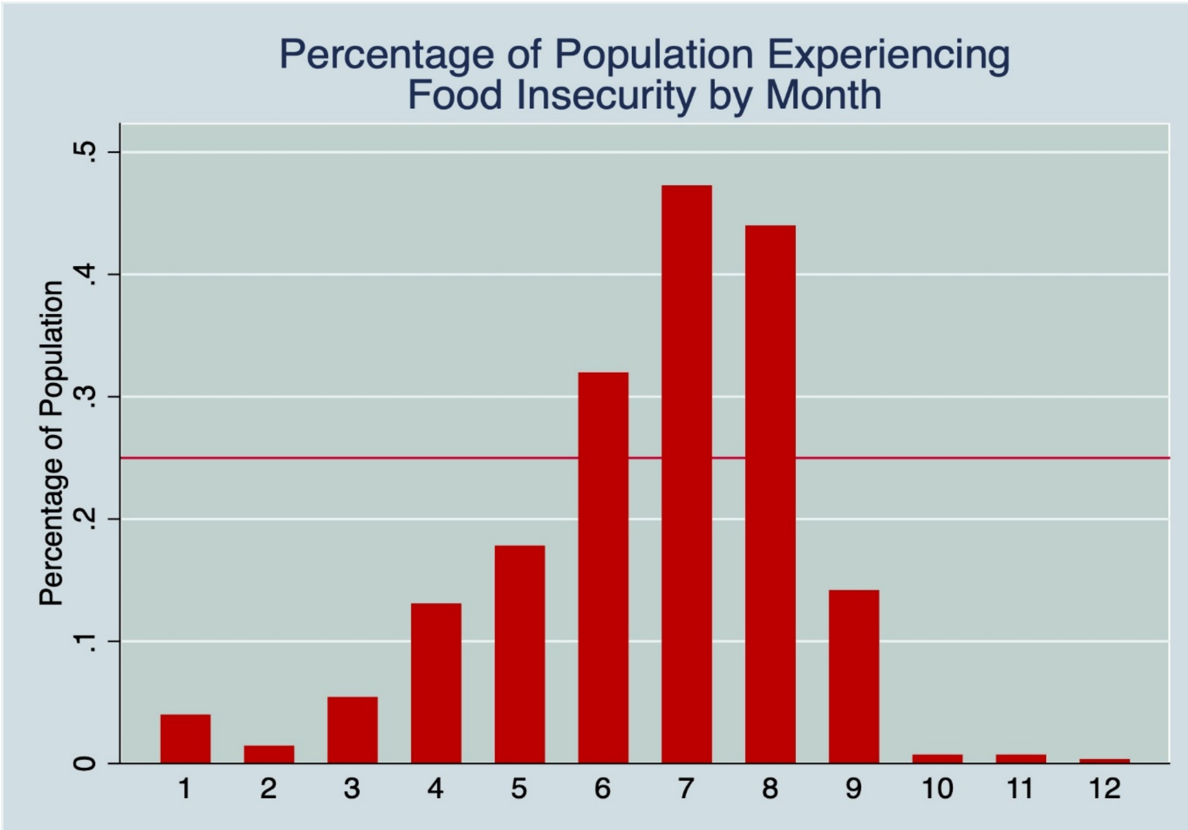


Table 5. Monthly variation in Food Insecurity

	(1) Baseline		(2) Household FE		(3) Demographic Controls	
VARIABLES	**Food Insecurity**	**se**	**Food Insecurity**	**se**	**Food Insecurity**	**se**
February	**-0.0255***	(0.0131)	**-0.0255***	(0.0131)	**-0.0255***	(0.0131)
March	**0.0145**	(0.0163)	**0.0145**	(0.0163)	**0.0145**	(0.0163)
April	**0.0909*****	(0.0233)	**0.0909*****	(0.0233)	**0.0909*****	(0.0233)
May	**0.138*****	(0.0265)	**0.138*****	(0.0265)	**0.138*****	(0.0265)
June	**0.280*****	(0.0313)	**0.280*****	(0.0313)	**0.280*****	(0.0313)
July	**0.433*****	(0.0341)	**0.433*****	(0.0341)	**0.433*****	(0.0342)
August	**0.400*****	(0.0342)	**0.400*****	(0.0342)	**0.400*****	(0.0343)
September	**0.102*****	(0.0251)	**0.102*****	(0.0251)	**0.102*****	(0.0251)
October	**-0.0327****	(0.0130)	**-0.0327****	(0.0130)	**-0.0327****	(0.0130)
November	**-0.0327****	(0.0130)	**-0.0327****	(0.0130)	**-0.0327****	(0.0130)
December	**-0.0364*****	(0.0124)	**-0.0364*****	(0.0124)	**-0.0364*****	(0.0125)
Female					**0.00832**	(0.0146)
Age					**0.00182*****	(0.000596)
Secondary Education					**0.0288**	(0.0191)
High School Education					**0.0366***	(0.0217)
Family Size					**0.000276**	(0.00232)
Dependents					**-0.00459***	(0.00262)
Cooperative Member					**0.0112**	(0.0145)
Years of Coffee Experience					**-0.00118***	(0.000657)
Constant	**0.0400*****	(0.0119)	**0.0400*****	(0.0134)	**-0.0268**	(0.0365)
Observations	3,300		3,300		3,300	
R-squared	0.208		0.296		0.212	
Household FE	NO		YES		NO	

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Effect of Honey Producers in Honey Season on Food Insecurity.

VARIABLES	(1) Treatment Baseline **Food Insecurity**	(2) Household FE **Food Insecurity**	(3) Demographic Controls **Food Insecurity**
Honey Producer	**0.00303**		**0.00543**
	(0.0181)		(0.0185)
Honey Season	**0.0925*****	**0.0925*****	**0.0925*****
	(0.0206)	(0.0206)	(0.0206)
Honey Producer x Honey Season	**-0.0719**	**-0.0719**	**-0.0719**
	(0.0448)	(0.0448)	(0.0448)
Female			**0.00868**
			(0.0145)
Age			**0.00179*****
			(0.000587)
Secondary Education			**0.0288**
			(0.0189)
High School Education			**0.0367***
			(0.0218)
Family Size			**0.000425**
			(0.00232)
Dependents			**-0.00448***
			(0.00257)
Cooperative Member			**0.0136**
			(0.0152)
Years of Coffee Experience			**-0.00116***
			(0.000650)
Constant	**0.131*****	**0.131*****	**0.0617***
	(0.00723)	(0.00457)	(0.0344)
Observations	**3,300**	**3,300**	**3,300**
R-squared	**0.010**	**0.098**	**0.015**
Household FE	**NO**	**YES**	**NO**

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 6. Parallel Trends Estimation of Outcomes.

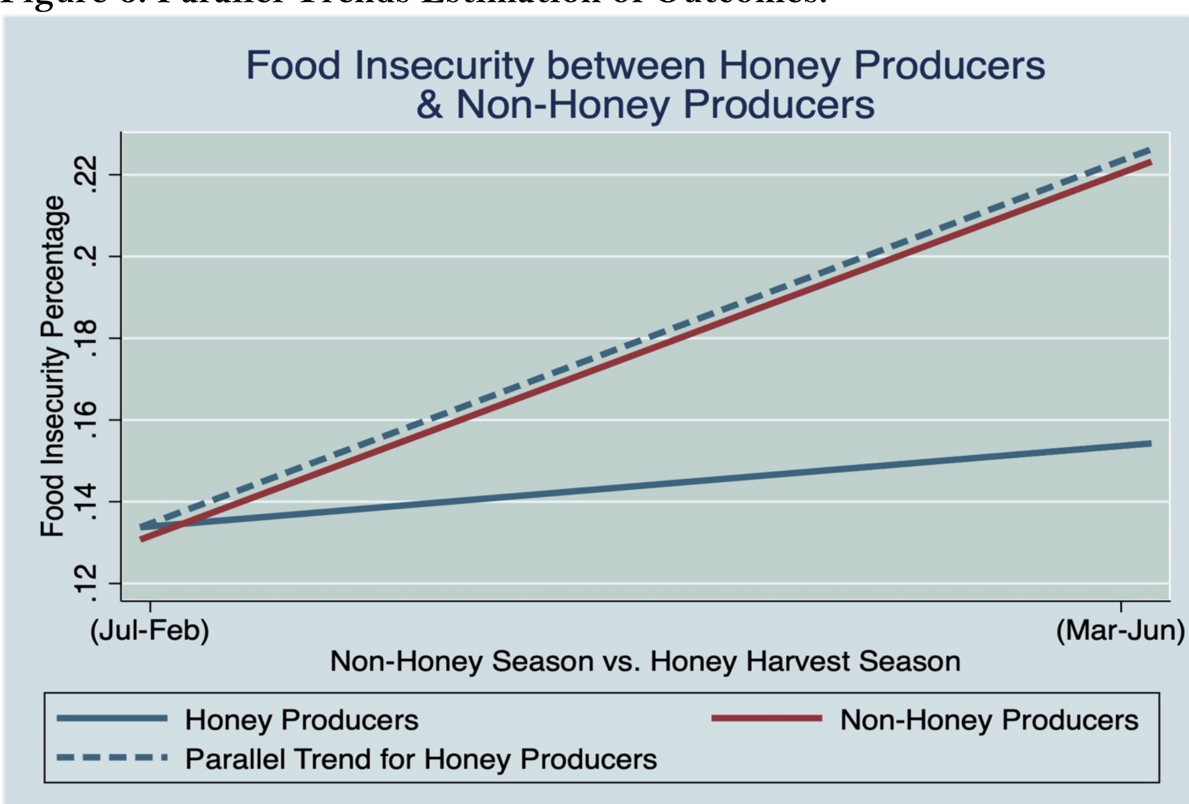


Table 7. Instrumented DiD with First Stage check on Instrument.

	(1)	(2)	(3)
	DiD	First Stage	IV
VARIABLES	**Food Insecurity**	**Honey Producer**	**Food Insecurity**
Honey Season x Honey Producer	**-0.0719**		**-0.188****
	(0.0448)		**(0.0804)**
Honey Season	**0.0925*****		**0.115*****
	(0.0206)		**(0.0267)**
IV: Honey Producers in Region		**0.900*****	
		(0.0952)	
Constant	**0.131*****	**0.0195**	**0.131*****
	(0.00457)	**(0.0280)**	**(0.00462)**
Observations	**3,300**	**275**	**3,300**
R-squared	**0.098**	**0.247**	
Individual FE	**YES**	**NO**	**YES**
F-Statistic		**89.50**	
Number of Individuals	**275**	**275**	**275**

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8. Robustness Check: Instrumented DiD with Lean Season as Treatment Period.

	(1)	(2)	(3)
	DiD	First Stage	IV
VARIABLES	**Food Insecurity**	**Honey Producer**	**Food Insecurity**
Lean Season x Honey Producer	**-0.00635**		**-0.0832**
	(0.0541)		**(0.117)**
Lean Season	**0.348*****		**0.363*****
	(0.0254)		**(0.0325)**
IV: Honey Producers in Region		**0.900*****	
		(0.0274)	
Constant	**0.0642*****	**0.0195****	**0.0642*****
	(0.00561)	**(0.00806)**	**(0.00563)**
Observations	**3,300**	**3,300**	**3,300**
R-squared	**0.263**	**0.247**	
Household FE	**YES**	**NO**	**YES**
Number of Individuals	**275**	**275**	**275**

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 7.

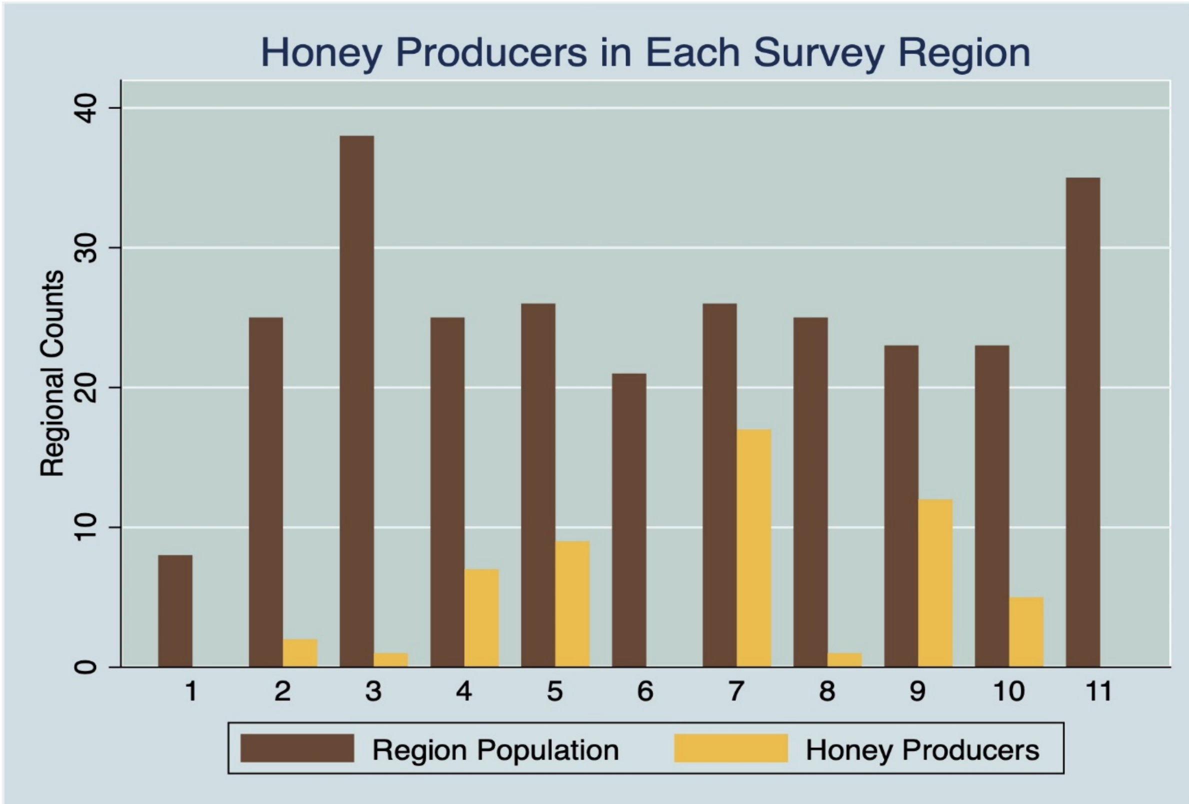


Figure 8.

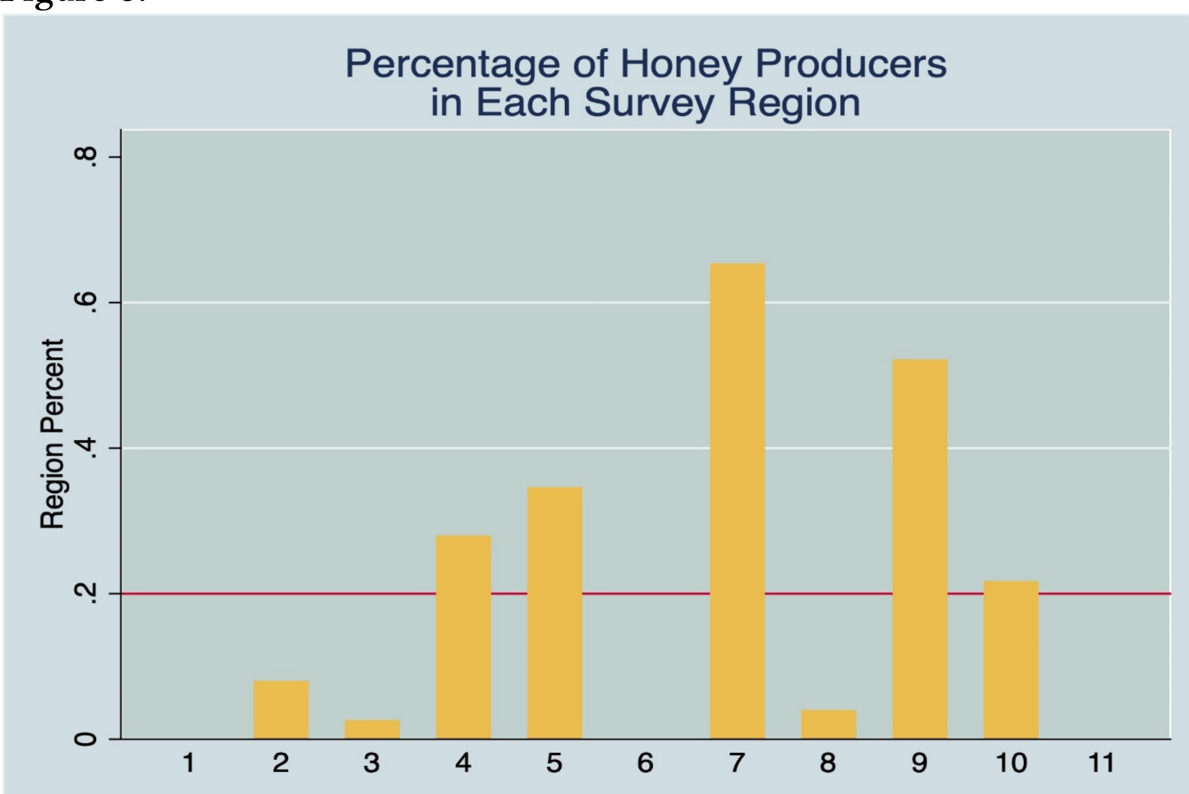


Figure 9.

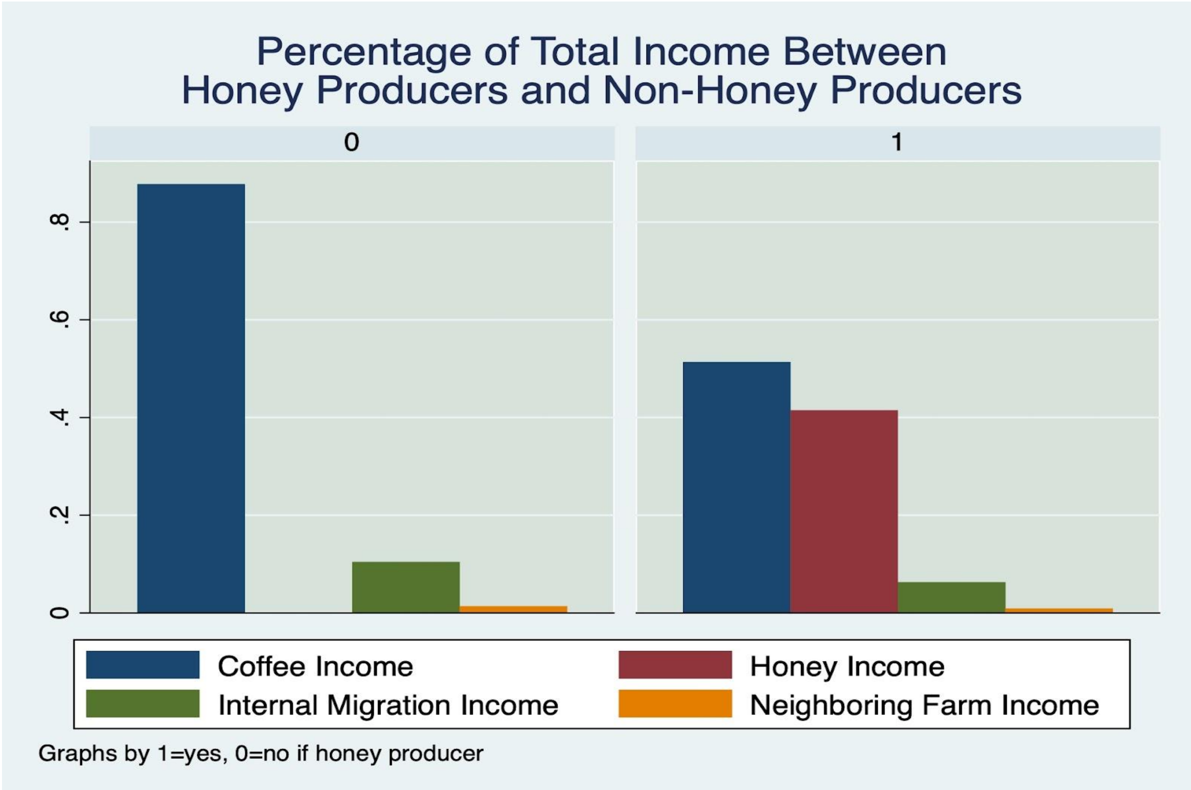


Figure 10.

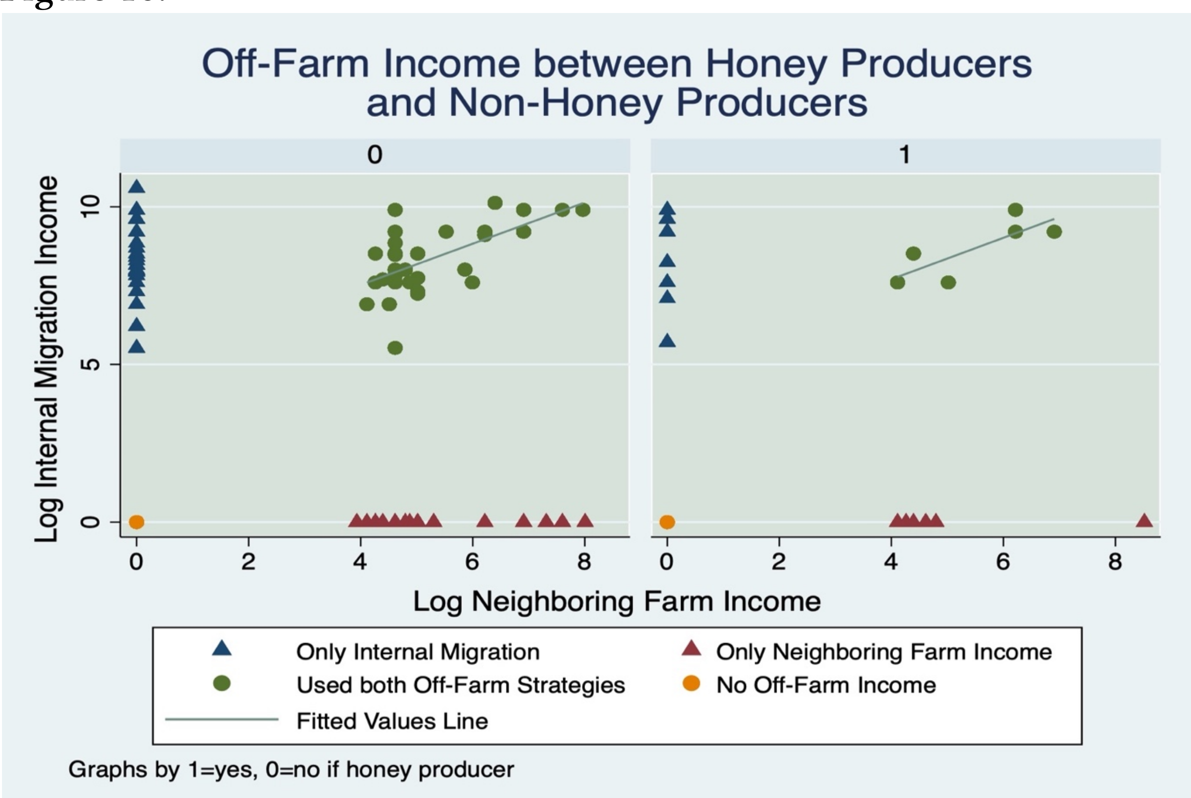


Figure 11. Honey Regions

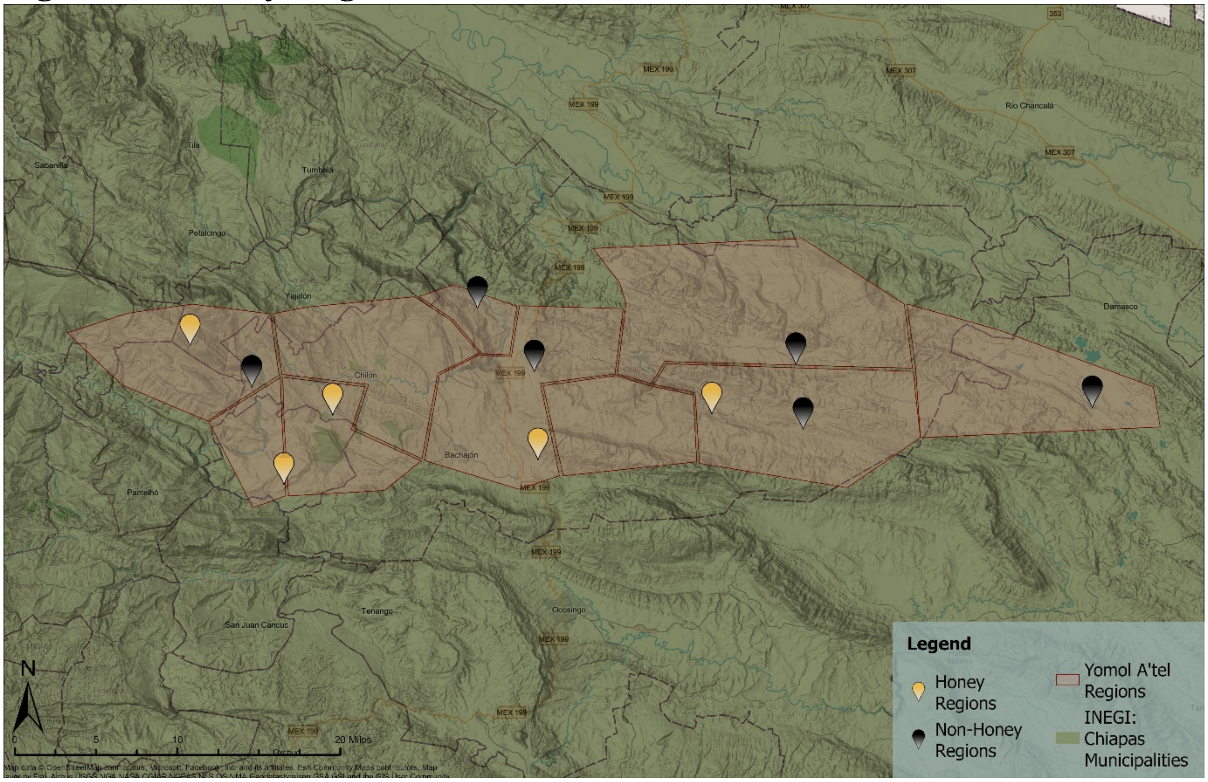


Figure 12. Honey Producer Regional Density

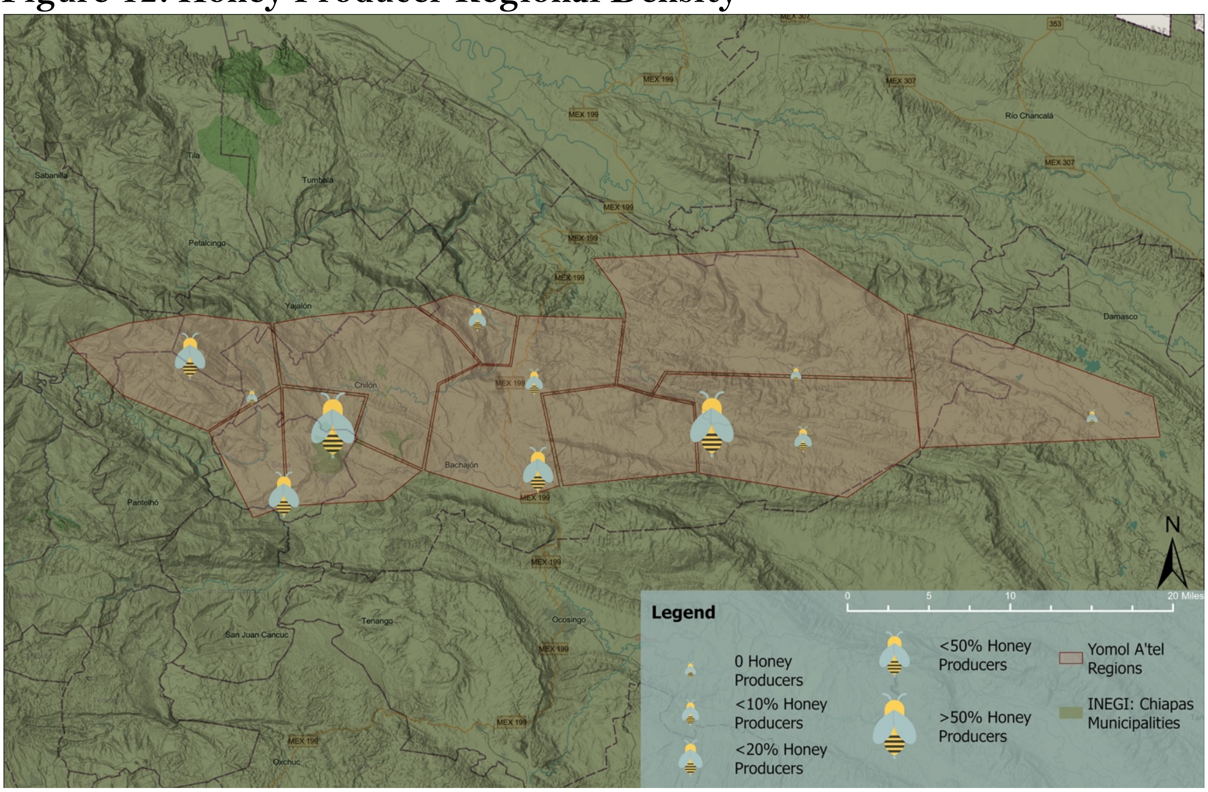


Figure 13. Regional Mean Food Insecurity Duration

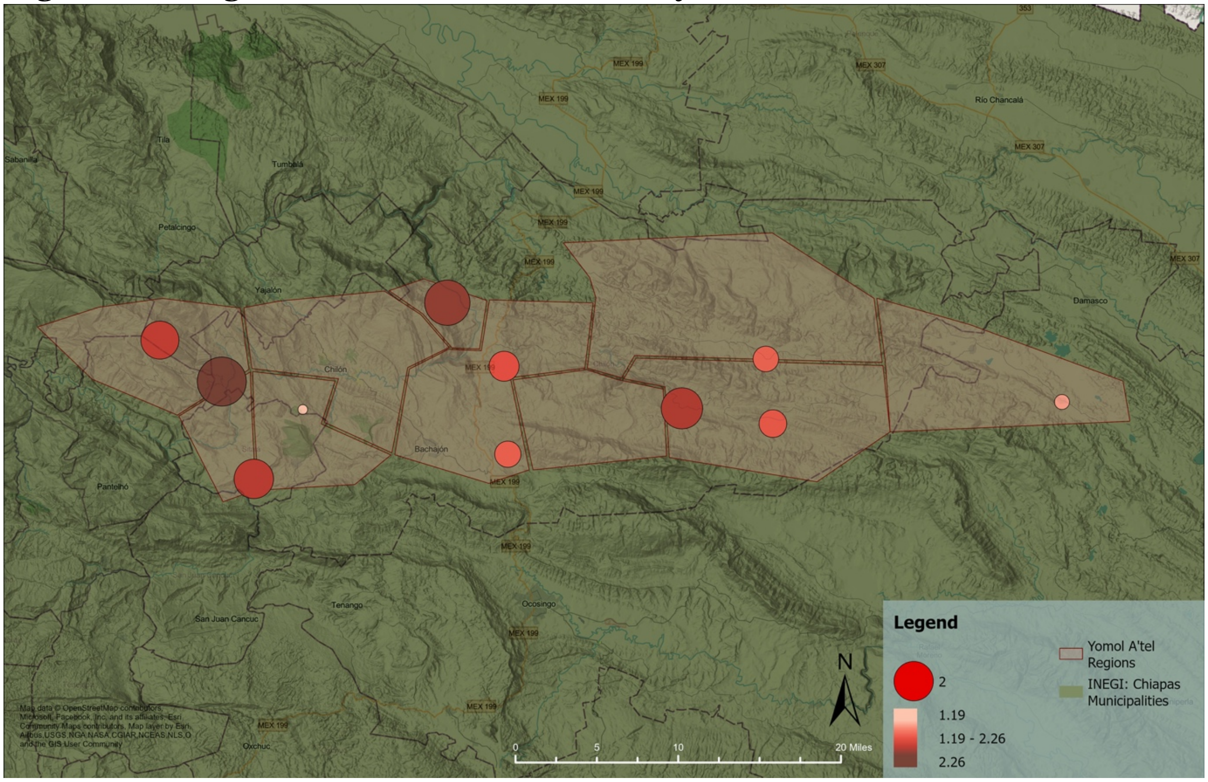
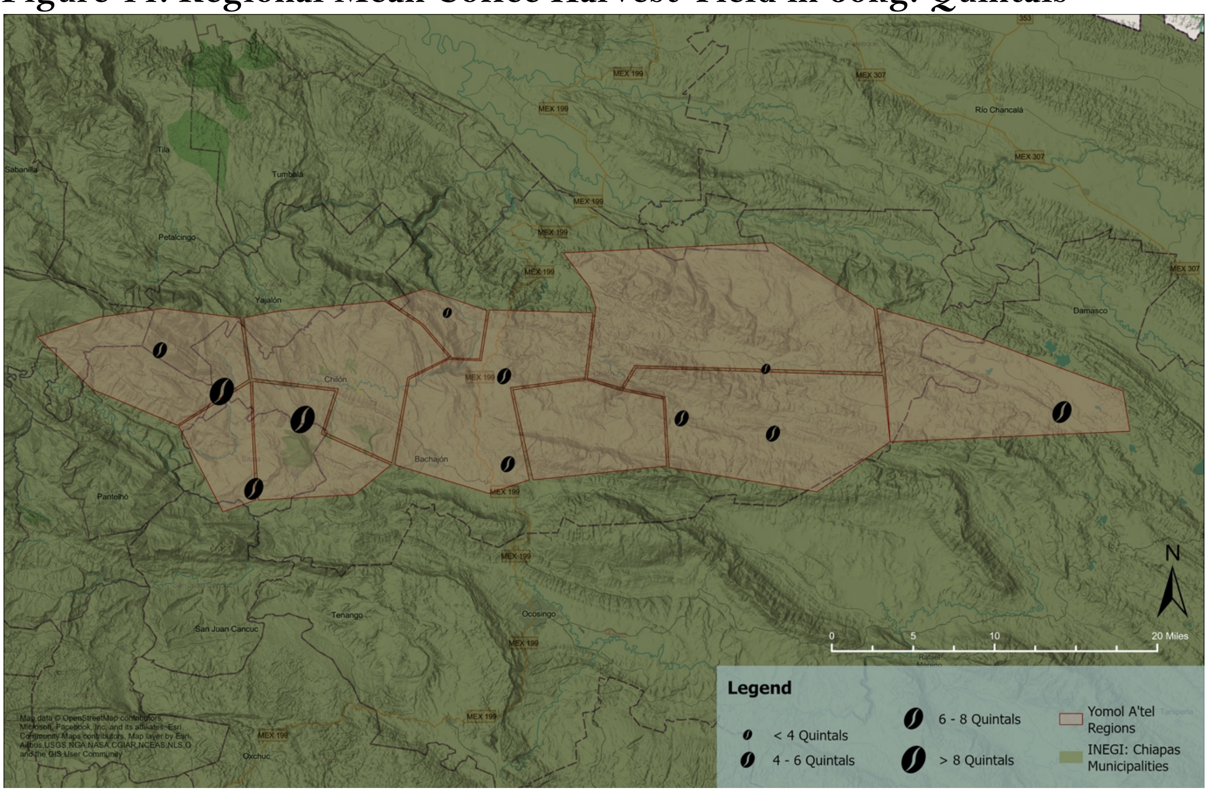


Figure 14. Regional Mean Coffee Harvest Yield in 60kg. Quintals



Survey Questions.

Edad:

Nivel educativo:

- ○ Primaria
- ○ Secundaria
- ○ Prepatoria
- ○ Universidad

¿Cuántos miembros hay en su hogar?

(que residen permanentemente)?

¿Cuántos de ellos son mayores de 65 años?

¿Cuántos de ellos son menores de 12 años?

¿Cuánto dinero recibió por la venta de sus cultivos el año pasado?

¿Usted o algún miembro del hogar ha trabajado por pago en la milpa de otra familia el año pasado?

- ◉ Sí
- ○ No

¿Cuánto recibió/recibieron como pago?

(Si sí)

¿Usted o algún miembro del hogar ha trabajado por pago en otra ciudad dentro de México el año pasado?

- ◉ Sí
- ○ No

» ¿Cuántos de los siguientes animales tiene usted?

Aves de corral

(gallinas, guajolotes, pollos, gallos)

Caballos

Mulas

Burros

Borregos, Ovejas, Chivos

¿Cuáles de los siguientes cultivos tiene usted actualmente?

- [ ] Maíz
- [ ] Frijol
- [ ] Café
- [ ] Calabaza
- [ ] Chayote
- [ ] Chile
- [ ] Plátano
- [ ] Caña de azúcar
- [ ] Naranja, Mandarina
- [ ] Yuca
- [ ] Camote
- [ ] Papaya
- [ ] Mango
- [ ] Hortalizas (Mostaza, Hierba Mora, Hierba Santa)
- [ ] Verduras (Lechuga, Repollo, Rábano)

¿Cuántas hectáreas en total tiene usted?

Aproximadamente, ¿qué porcentaje de la producción de su milpa es para el propio consumo de su familia?

0 100

Si usted tuviera suficiente dinero, ¿qué actividad preferiría realizar?

¿Cuántos años lleva cultivando café?

¿Cuáles variedades de café tiene usted en su milpa actualmente?

- ☐ Typica (o criolla)
- ☐ Bourbón
- ☐ Maragogype
- ☐ Geisha
- ☐ Tabi
- ☐ Caturra
- ☐ Mundo Novo
- ☐ Garnica
- ☐ Catimor
- ☐ Pacamara
- ☐ Oro Azteca
- ☐ Robusta

¿Cuánto café cosechó el año pasado? (kg)

(1 quintal = 60kg)

¿Cuánto café vendió a intermediarios el año pasado?

Unidad

- ○ Kilo (kg)
- ○ Quintal (60kg)

¿Cuál es el precio más alto que recibió de un intermediario el año pasado?

Precio

¿Cuánto café vendió a una cooperative el año pasado?

Unidad

- Kilo (kg)
- Quintal (60kg)

¿Cuál es el precio más alto que recibió de una cooperativa el año pasado?

Precio

Unidad

- Kilo (kg)
- Quintal (60kg)

¿Cómo le vende su café a la cooperativa? Puede seleccionar mas de uno.

¿Cuál es el mejor precio que ha recibido por su café?

Precio

Unidad

- Kilo (kg)
- Quintal (60kg)

¿Cuál es el peor precio que ha recibido por su café?

Precio

Unidad

- Kilo (kg)
- Quintal (60kg)

¿Usted produce miel?

- (•) Sí
- ( ) No

¿Cuántos kilos produjo el año pasado?

¿Cuál es el mejor precio que ha recibido por su miel?

Precio

¿Usted conoce a alguien que produzca miel?

- ( ) Sí
- ( ) No