Agricultura, Sociedad y Desarrollo

RETROSPECTIVE ANALYSIS OF THE ADOPTION OF HYBRID CORN SEEDS IN THE STATE OF TLAXCALA

Bertha Sofía **Larqué-Saavedra**[1*], Ana Lid **del Ángel-Pérez**[2], Fabián **Islas-Gutiérrez**[3], Nelda Guadalupe **Uzcanga-Pérez**[4], David Heber **del Valle-Paniagua**[5], Israel **Rojas-Martínez**[6]

[1]Campo Experimental Valle de México-INIFAP. Km. 13.5 Carretera Los Reyes-Texcoco, Estado de México. 56250.
[2]Campo Experimental Cotaxtla-INIFAP. Km. 34 Carretera Federal Veracruz Córdoba. Veracruz. 91700.
[3]Campo Experimental Valle de México-INIFAP. Km. 13.5 Carretera Los Reyes-Texcoco, Estado de México. 56250.
[4]Campo Experimental Mocochá. kilómetro 25 de la antigua carretera Mérida–Motul, Municipio de Mocochá. 97454.
[5]Campus Montecillo-Colegio de Posgraduados. Km. 36.5 Carretera México-Texcoco, Montecillo. 56230.
[6]Sitio Experimental Tlaxcala. Km. 2.5 Carretera Tlaxcala-Santa Ana Chiautempan, Colonia Industrial. 90800. Tlaxcala, Tlax.
*Corresponding author: larque.bertha@inifap.gob.mx

Citation: Larqué-Saavedra BS, Del Ángel-Pérez AL, Islas-Gutiérrez F, Uzcanga-Pérez NG, Del Valle-Paniagua DH, Rojas-Martínez I. 2022. Retrospective analysis of the adoption of hybrid corn seeds in the State of Tlaxcala. Agricultura, Sociedad y Desarrollo https://doi.org/10.22231/asyd.v19i4.1362

ASyD 19(4): 405-420

Editor in Chief:
Dr. Benito Ramírez Valverde

Received: October 23, 2020.
Approved: September 22, 2021.

Estimated publication date:
January 27, 2023.

ABSTRACT

The Ministry of Agriculture and Rural Development (*Secretaría de Agricultura y Desarrollo Rural*, SADER) continues the search for increased yields and profitability of corn. To achieve this, among other actions, it bets on the adoption and sowing of hybrid corn. In the market, there are transnational and national companies, and producer groups that produce these seeds. Transnational companies have taken theirs to different states. To Tlaxcala among others, where seeds were marketed since 1984 from these companies and others obtained by INIFAP. In 2011 with the MasAgro Program, work was done to obtain new seeds in the entity. However, the level of adoption is low. The objective of this study was to identify the characteristics of the farmers who show a willingness to sow them. The focus of this sociological study was fieldwork to obtain direct information from farmers in 17 municipalities in the state of Tlaxcala. The information was analyzed with the Chi-square statistic and a logistic regression. The results and conclusions show that farmers who know hybrid seeds and whose objective is to sell are willing to plant them. All of them (100%) prefer native seeds for family and animal consumption. Native corn today continues to be in demand in the Tlaxcala market.

Keywords: family production unit, native corn, tastes and preferences.

INTRODUCTION

In the current government's six-year period, SADER made the decision of continuing to implement the MasAgro program. This program seeks the sustainable intensification of corn and wheat production, as well as the increase in profitability and the stabilization of yields (CIMMYT and SADER, 2019). According to CIMMYT (2019), at the national level there are 64 corn hybrids, which are multiplied by more than 60 small-scale seed companies promoted by MasAgro. Within this framework, this study takes on importance since in recent years INIFAP formed small seed companies in the state of Tlaxcala. They began their sales with success, due to support from the Federal Government, but currently they are facing strong problems that place their continuity at risk, since they are immersed in an oligopoly market formed by transnational companies without support from the government (Larqué *et al.*, 2017).

One of the main components of MasAgro is producing new hybrids, transferring them and promoting their adoption. Therefore, a retrospective analysis of the adoption of hybrid

corn is worthwhile, both from INIFAP and from transnational companies with presence in the state of Tlaxcala. Work was conducted in that state, even when it had already been studied (Damián *et al.*, 2007; Donnet, 2012; García-Salazar and Ramírez-Jaspeado, 2013) because researchers from the Valle de México Experimental Field (CEVAMEX) – INIFAP have obtained hybrid corn seeds that are apt for this state, and jointly with INIFAP's Experimental Site in Tlaxcala, they have carried out transference work since 2004.

This study was directed at understanding the adoption by knowing how long the farmers have been sowing hybrid corn seeds and the answer they have to the question: Do you like sowing hybrid corn seeds? This question was handled as dependent variable. The objectives of this study were: to characterize the corn farmers in the state of Tlaxcala, and to identify the characteristics of corn producers in Tlaxcala that are statistically related with the study variable.

Adoption is a theme that is widely studied (Byerlee and Hesse, 1982; Cáceres *et al.*, 1997; Cadena - Íñiguez *et al.*, 2018); it is defined as an appropriation process that considers cognitive changes as prerequisite (Leeuwis, 2000, cited by Cadena-Íñiguez *et al.*, 2018, p. 857). Galindo (2004 cited by Velázquez, *et al.,* 2019, p.104) states that the adoption of technology is a mental process that begins with the procurement of information about an innovation and then the decision of accepting it or rejecting it. According to Orozco *et al.* (2009), "the variables that influence adoption are: 1) cognitive change, 2) level of cosmopolitism, 3) contact with agriculture and livestock institutions, 4) participation in external projects, 5) contact with input distributors, 6) age, 7) schooling, 8) attitude towards innovation, 9) exposure to communication media, 10) extra-farm income, 11) level of life, 12) level of training, 13) available economic resources, 14) relationship with agents of change, 15) hectares cultivated, 16) agroclimatic environment, 17) years of living in the residence zone, and 18) relevance of technology" (p. 552).

It is considered that "the process of acceptance and adoption of technologies has multi-causal origin, and exogenous factors intervene, such as training, leading policies, financing and market of the product, as well as endogenous factors such as social organization, division of labor by sex and age, income, economic activities, and agricultural knowledge, among others" (Aguilar, 2008, p. 4).

It is defined as the producer's decision to use or not to use a technology in the production process. It is said that there is adoption when the producers have integrated the technology promoted (Sagastume *et al.*, 2006). Technology is a means that acts on nature, and in the construction of society and human relationships; "technology should not be considered as a mere scientific product, with neutral impact on the societies that use it" (Ferguson, 1994, cited by Cáceres *et al.*, 1997). "Technology leads to a set of social behaviors that act on society" (Pfaffenberger 1988, cited by Cáceres *et al.*, 1997). Therefore, "when considering the transference of technology from one society to another, in truth it is the impact of one type of behavior on another that they are talking about" (MacKenzie and Wajcman 1985 cited by Cáceres *et al.*, 1997). The concept of technology adoption refers to technologies from outside the production units, and they constitute a sub-set of the totality of technological innovations, introduced by producers in their farms. Cáceres

et al. (1997) consider that producers are constantly innovating with technologies that they develop, in contrast with adoption which refers to technologies brought in from the outside.

METHODOLOGY

This is an analytical study that had the adoption as study object, and as subjects of study the farmers of corn grain and fodder from the following municipalities: 1. Acuamanala de Miguel Hidalgo, 2. Altzayanca, 3. Apizaco, 4. Calpulalpan, 5. Cuapiaxtla, 6. Españita, 7. Huamantla, 8. Ixtlacuixtla de Mariano Matamoros, 9. Nanacamilpa de Mariano Arista, 10. Nativitas, 11. Panotla, 12. Sanctorum de Lázaro Cárdenas, 13. Santa Ana Nopalucan, 14. Tepetitla de Lardizábal, 15. Terrenate, 16. Xicohtzinco, and 17. Zacatelco, from the state of Tlaxcala (Figure 1). These municipalities were selected intentionally, because that is where INIFAP researchers have transferred the hybrid corn seeds obtained by this institute.

Desk work was carried out starting with a bibliographic review about the theme. Field work was conducted, using as technique questionnaires with open and closed questions, to obtain qualitative and quantitative information. The analysis variables were the dependent variable and 18 independent variables. Semi-structured interviews were made with key informants.

Sample size. Stratified random sampling was used with proportional allotment to the size of the population of each municipality (Montesinos-López, *et al.,* 2009, p 129).

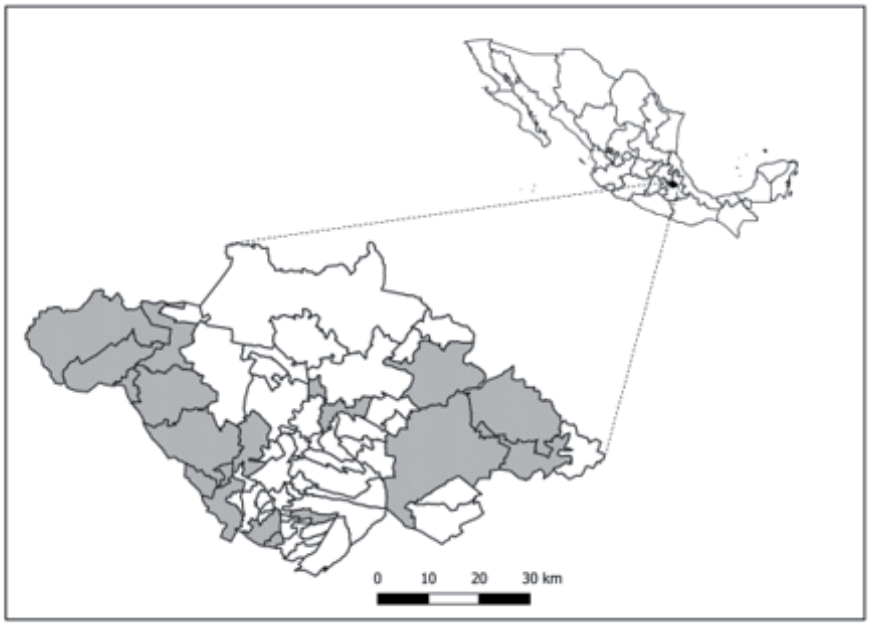


Figure 1. Municipalities in the state of Tlaxcala to which the corn grain and fodder farmers surveyed belong.

The sampling framework was made up by the list of corn producers that were beneficiaries from PROCAMPO in 2015, in the municipalities of study. The total of producers was 5297. A level of confidence of 95% was used, estimation error of 10%, and a value of p=0.5. The following formula was applied

$$n = \frac{Nz^2 pq}{(N-1)e^2 + z^2 pq} \quad (1)$$

where N: population size; n: sample size; p: probability of having yes as an answer; q: probability of having no as an answer; z: level of confidence; e: accuracy (error).

Substituting the values, the following was obtained:

$$n = \frac{5267(1.96)^2 * 0.5 * 0.5}{5266(0.1)^2 + (1.96)^2 * 0.5 * 0.5} = 94.34$$

Therefore: n= 94.34
The stratification was carried out considering the number of producers by municipality. The following formula was applied:

$$n_h = n\frac{N_h}{N} \quad (2)$$

where N: population size; N_h: size of each stratum (municipality); n: sample size; n_h: size of each stratum (municipality).

The selection of farmers was done randomly with equal probability. Once the list was known, it was refined with the support of a technician who made visits to validate that they were actually sowing corn on their lands. Finally, 104 questionnaires were applied. Both activities (visiting and applying questionnaires) were carried out during the second semester of 2016 and the first four months of 2017.
To apply the interviews, the interview respondents (key informants) were selected intentionally, under the criterion that they were people who could offer relevant information, due to their work and knowledge about the study theme.
The analysis of the field information was made with Chi-square tests between the dichotomous dependent variable, Do you like sowing hybrid corn seeds?, and 19 independent variables that were handled as ordinary, nominal and numerical.
The null hypothesis was independence between the variables. A second step was to work with a logistic regression, using the variables that were rejected by the Chi-square test as explanatory of the dependent variable. The logistic model had the following expression:

$$p = \frac{1}{1 + \exp(-\alpha - \beta_1 x_1 - \beta_2 x_2 - ... - \beta_k x_k)}$$

Where p is the probability that the variable of interest will happen, x_n are the explanatory variables, and β_n the parameters of the model.

The stepwise procedure was used to identify the best regression model. The tests were carried out with the SAS 9.3 statistical package.

RESULTS AND DISCUSSION

Corn in the state of Tlaxcala

The state of Tlaxcala is located in the center of the country. It has a long tradition in the cultivation and consumption of corn. In the state, corn occupies the largest surface sown, approximately 117,381 thousand hectares (SIAP, 2021). According to official information, from 2015 to 2018, grain corn was sown in all the municipalities of the state. Based on the surface sown, the following stood out: Huamantla with 14,688.5 ha, Tlaxco with 8,393.5 ha, Altzayancan 7,442.3 ha, and Calpulalpan 4,643.0 ha. The Rural Development District (RDD) that showed the largest surface sown in this same period was RDD 165 Huamantla with 43,977.25 ha. (Average data from the period based on information obtained from SIAP, 2021).

From 2013 to 2019, the annual yields were within a range of 1.5 to 3.0 tons per hectare (SIAP, N.A.). These yields could be obtained from the type of soil and seed used. The soils in the state are: Phaeozem soils dominate in the northern part, and to a lesser extent Andosol and Luvisol. In the central-west part, Leptosol predominate and to a lesser extent Durisol and Cambisol. In the center and south-center, Luvisol predominates. In the center-east and southeast part, the soils that predominate are Fluvisol, Regosol, Arenosol, Luvisol. At the state level, the higher percentage (30%) is Phaeozem soils, followed by Leptosol (10.95 %) and Durisol (9.22 %) (INEGI, N.A., Map 11) "Of the surface, 90% shows some degree of erosion" (AMSDA, N.A., p. 6).

The seed that producers use is not high-yield. Barillas (2010) states that, in 2010, 90% of the state surface planted with corn was sown with native seed, which corresponds to 72,891.9 ha (datum calculated based on SIAP, 2021). García (2014) presents an average figure regarding the amount of "Creole" seed sown in the state of Tlaxcala during the period of 2008 to 2010, and based on this, the percentage of participation was calculated to be 60%. This situation is present even when seeds from INIFAP's hybrid corn have been traded since 1984 (Barillas, 2010, p. 10), and also from private, national and foreign companies. With the closing of the National Seed Producer (*Productora Nacional de Semillas*, PRONASE), the Ministry of Agriculture, Livestock Production, Rural Development, Fishing and Food (*Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación*, SAGARPA) continued in 2004 with the promotion of certified hybrid corn seeds; it worked jointly with INIFAP, and created the program of "Certified Seed Production for the State of Tlaxcala" (Barillas, 2010). In this program, INIFAP trained and formed individual producers, producers' organizations, and small-scale companies that produced certified seeds. The seeds were distributed through the Corn and Bean Program (*Programa Maíz y Frijol*, PROMAF). For their part, the seeds from

private companies, primarily transnational ones, achieved greater presence. Recounting, the following seeds were already known in the market: Halcón, Gavilán, Cóndor and Búho traded by Asgrow; AS-721, AS-820, AS-600 and from INIFAP H-30, H-33, VS-22, V-23 (then, H-30 and H-33 left the market and H-40 and H-48 entered) by Aspros; Monsanto with Z-60 and PROMESA with Texcoco seeds (AMSDA, N.A. and Larqué *et. al*., 2017, p. 1475). With the closing of PROMAF, the Program of Incentives for Corn and Bean Producers (*Programa de Incentivos para Productores de Maíz y Frijol*, PIMAF) began, working with the same plan. Approximately for six years, small-scale seed producers trained by INIFAP sold to SAGARPA, and in turn, it sold to producers at subsidized prices. The seed producers delivered from 12 to 14 thousand bags of seeds per year to the government. With this amount, 13 thousand hectares were sown annually (Larqué *et al*., 2017, 1475). The situation changed starting in 2012, when the Federal Government withdrew from the seed trade and left it in the hands of the market made up by private companies certified by SAGARPA (SAGARPA, 2014). The state government, in turn, through the Ministry of Agriculture and Livestock Promotion (*Secretaria de Fomento Agropecuario*, SEFOA), promotes the use of improved seeds, placing the offer at producers' disposal, through the seed *tianguis* in the state. Transnational oligopoly companies participate in this *tianguis*, as well as medium and small scale national seed companies.

Study variables

The independent variables were classified into three groups. The first referred to personal characteristics of the producer. The second to variables which refer to their economic activity. The third group to variables related to religious customs that producers have towards native corn seeds, knowledge that they have about some hybrid corn races being obtained by research and education institutions established in Mexico, and the relationship that they have with these institutions (Table 1).

Characteristics of the producers and the RDD that they belong to

The municipalities from the sample to which the corn grain farmers belong were located in the three Rural Development Districts (RDDs) of the state. In the year 2000, the RDD 165 Huamantla had the highest marginality at the state level. By 2015, it changed to low or medium marginality according to the municipality (Table 2). The National Population Council (*Consejo Nacional de Población*, CONAPO) considered in 2010 that marginality was a structural phenomenon that values the intensities of exclusion in the development process. Four indicators were used to measure this exclusion, one of them income; earning up to two minimum wages was a way of exclusion and therefore of marginality (CONAPO, 2020. a) By 2015, it was suggested that two minimum wages constituted the lower limit for people to have access to basic articles related to the social expenditure of the State (such as education and health) (CONAPO, 2020 b).

In 14 of these 17 municipalities, more than 50% of the population earned up to two minimum wages. In 2015 the general minimum wage for zone B, to which the state of Tlaxcala belonged, was 68.28 pesos daily (pesos from 2015) (CONASAMI, 2015); if two minimum wages were

Table 1. Study variables.

Variable	N	DF	Chi square		Observation
			Value	Prob	
Age	102	3	5.05	0.1682	
Marital Status	61	2	5.644	0.0595	
Number of economic dependents	93	1	8.6743	0.0032	
Scholarship	102	2	2.5216	0.2834	
Production destination	101	1	16.0502	<.0001	
Productive activities	95	2	1.4659	0.4805	
Activity from which he obtains his main income	94	3	2.9732	0.3958	
Type of property	97	2	1.4878	0.4753	
Hectares planted	102	3	6.4395	0.0921	
Water regime (Irrigation/ temporary)	97	1	8.9998	0.0027	50% of the cells have counts less than 5
Rent Land to sow	100	1	9.042	0.0026	
Farmer born in this municipality	102	1	6.2769	0.0122	
Rooted by customs around corn	95	3	13.8947	0.0031	38% of the cells have expected counts less than 5
You know that the UACH, CP, CIMMYT and INIFAP carry out research to obtain improved seeds	102	1	28.5068	<.0001	
Approach with these research institutions	78	2	21.2148	<.0001	50% of the cells have expected counts less than 5
Reasons farmer doesn't like to sow hybrid seeds	38	2	10.4952	0.0053	50% of the cells have expected counts less than 6
Sowing of hybrid seeds	102	1	10.1718	0.0014	
Creole corn is the same that you have been planting for 30 years or is it foreign seed	91	1	5.4026	0.0201	25% of the cells have expected counts less than 5
Aspects that you like about the behavior in the field of the Creole corn seed	84	4	6.1941	0.1851	

considered, as CONAPO suggests, they earned $124.56 per day and $3,736.8 per month. With this income, they covered the needs of a family which, on average, was made up of four people, according to information provided by the producers in the survey.

Economic activities

Of the farmers from the sample, 100% are devoted to corn cultivation. None declared that their production would be destined 100% to the market. The characteristic that

Table 2. Marginalization level of the municipalities to which the farmers in the sample belong and percentage of the population with two minimum wages (2015).

Municipality	DDR	Marginalization level	% of employed population with income of up to two minimum wages
Acuamanala de Miguel Hidalgo	164	Low	65.09
Altazayanca	165	Medium	68.48
Apizaco	164	Very low	42. 31
Calpulalpan	163	Very low	51.30
Cuapiaxtla	165	Low	59.49
Españita	163	Medium	66.01
Huamantla	165	Low	57.02
Ixtlacuixtla de Mariano Matamoros	164	Low	51.49
Nanacamilpa de Mariano Arista	163	Low	62.40
Nativitas	164	Low	57.76
Panotla	164	Very low	42.30
Sanctorum de Lázaro Cárdenas	163	Low	57.87
Santa Ana Nopalucan	164	Low	52.42
Tepetitla de Lardizábal	164	Low	54.73
Terrenate	165	Medium	60.87
Xicohtzinco	164	Very low	44.86
Zacatelco	164	Very low	53.61

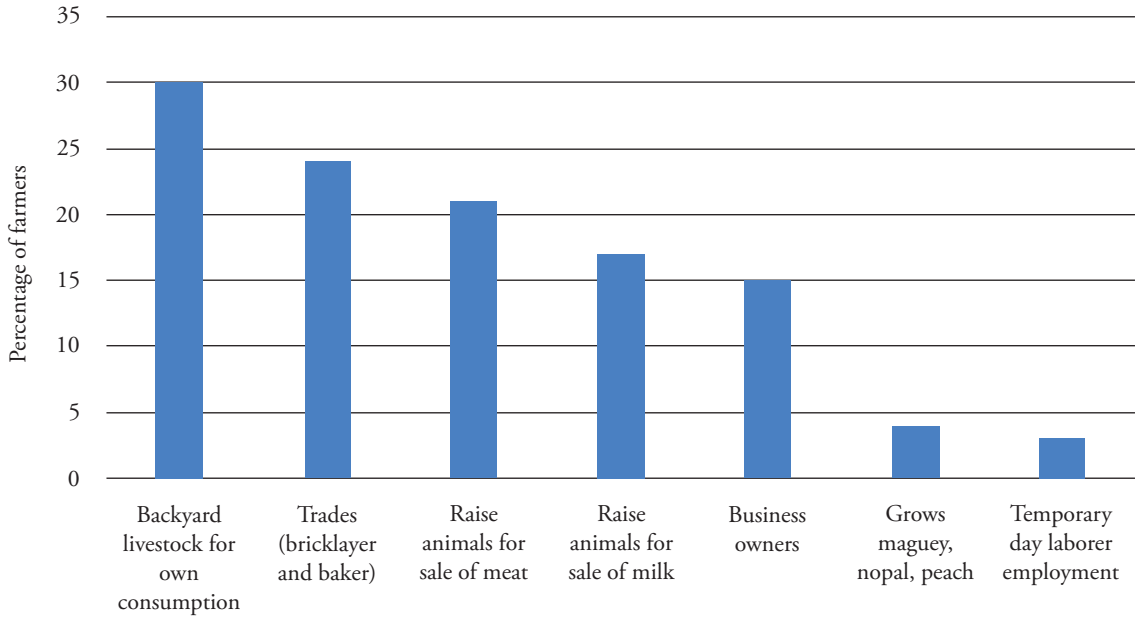
Source: prepared with data from CONAPO (2015).

predominated in 87.5% of the producers was that more than 50% of their corn production was for consumption in the household and the surplus for sale. Of the producers, 11.5% sold more than 50% of their production. This information agrees with that provided by Lazos (2014) who identified that in general (referring to Tlaxcala), native corns were destined to auto-consumption, for the livestock or to supply seed to the producer for the next cycle, while hybrid corns were directed more to the market. Pérez-Sánchez *et al.* (2017) mention that in the municipality of Atlangatepec, Tlaxcala, the corn-producing families are classified into: those that produce for self-supply, for semi-supply and the loss-making, with the first being the most frequent. This classification defines clearly the destination of the corn harvest in these families.

Of the total of farmers in the sample, 26% said that agriculture is their only source of income. The remaining 74% said that they conduct other activities, in addition to sowing corn (Figure 2).

Within this group (those that combine sowing corn with other economic activities), 68% are also devoted to livestock production, which is the second activity that brings together more farmers, after corn sowing. Of these, 30% have backyard animals for family consumption and develop activities of their own in the Family Production Units (FPUs) in their traditional form, since with their production factors (capital, land and workforce) they produce for auto-consumption.

Of them, 21% breed animals for sale. These producers declared that they destine part of their corn harvest to family consumption, and another for livestock feed, whether as fodder, cobs, or corn grains, depending on the animals that they breed (cows, horses, pigs,



The sum of the percentage exceeds 100% because some farmers carry out more than one activity.
Source: prepared by the authors based on field information.
Figure 2. Percentage of farmers according to economic activities that they combine with sowing corn.

sheep, turkeys or hens). They do not have surplus. This is another strategy of the FPUs, they produce with double purpose: auto-consumption (in the case of corn) and sales (in the case of livestock). Finally, 17% are devoted to livestock breeding for milk sale. These function the same way as the aforementioned. Pérez *et al*. (2019) found in the locality of La Magdalena Cuextotitla from the municipality of Españita that agriculture is the main economic activity of the community, although the families complement their income with other activities such as commerce, services, and agricultural work in Canada and the United States, through temporary contracts, and therefore it is a location with high degrees of marginalization.

According to the opinion of most of the producers, the economic activity that generated the highest income was sowing corn (Table 3).

Damián *et al*. (2007) state that when a corn producer from Tlaxcala conducts complementary activities, this generates productive discontinuity and technological backwardness in the agronomic management of corn since it decreases their interest in improving their production technology. Based on this statement, the following was used as independent variable in this study: the producer carries out other productive activities in addition to corn sowing. The results show that there is no relation between this and the question: Do you like sowing hybrid corn seeds?

Another independent variable was: the farmer sells more than 50% of their corn harvest. In this case the regression did find a relation. The interpretation is that a farmer who sells to the market increases by 5.34 the probability of having a yes answer to the question:

Table 3. Percentage of farmers who expressed their opinion about the economic activity that generates the highest income.

Activity	Percentage of producers in the sample[1]
Corn production with more than 50% for own consumption	58
Corn production with more than 50% for sale	7
sale of milk	10
sale of meat	2
Own consumption livestock (chickens, sheep, pigs)	1
Own business	8
Laborer	1
Bricklayer	4
Baker	4
Cultivation of peach, maguey or cactus pear	2

[1]Three missing values
Source: own elaboration based on field information.

Do you like sowing hybrid corn seeds? This is in comparison to a farmer with production destined to auto-consumption in more than 50%.

Donnet (2012) suggests that producers who divide their harvest into auto-consumption and sales constitute a problem to develop a seed sector in Mexico, in addition to selling in underdeveloped markets. In a developed market, both seed production and hybrid corn grain production is addressed by producers with entrepreneurial vision: they sow improved seeds and their production is 100% for the market, working under contract. They sell large volumes with homogeneous quality and they are connected with developed trading channels. The predominant characteristic of farmers from the sample who sell more than 50% of their production is that they sow native or hybrid seed, and they attain average production volumes of 3 tons per hectare. They do not work under contract and deal with regional markets. They sell to stores in Huamantla or directly to livestock producers in the state of Veracruz. They share these characteristics with those who sell less than 50% of their corn grain, deal with local or regional markets through stores in Huamantla. They take "local" grains of heterogeneous size. Their production volumes are of 1.5 to 2 tons. Another form of sale is by selling kilograms of corn directly to the consumer, in their localities. In turn, Noniero and Massieu (2018) defined that the corn market in Tlaxcala is dynamic; they identified producers who are grain hoarders, who purchase from medium and small scale producers, intermediaries who work for large companies such as Cargill and Maseca; and, in parallel, farmers who produce for auto-consumption persist.

Land tenure

From the total of all the farmers in the sample, 11.1% are small-scale owners, 73.7% are *ejidatarios*, and 15.1% have smallholding and *ejido*; 78% sow corn on surfaces from 0.5 to 9 ha, with a bounded mean of 5.32 ha, median of 3 and mode of 2. According to Artís (N.A.), the producers from Tlaxcala are classified as smallholders, in the understanding that they own five hectares or less. Both the tenure regime and the size of the surface

they sow did not have a relationship with the dependent variable. García – Salazar and Ramírez – Jaspeado (2013) consider that the agricultural producers of Tlaxcala are far from being users of improved seeds, since a plot of at least 16.4 ha is required. In Tlaxcala, due to the size of their production units, a value of 40% of the Rate of Use of Improved Seed is reached, and 60% of the Rate of Use of Native Seed. Of the producers from the sample, 22% rent lands, with a bounded mean of 8.5 ha, median of 6.5 ha and mode of 12.5 ha. Of the farmers who rent lands, 68% sell more than 50% of their production and they have animals and sell milk or meat. Land rental was used as an independent variable in this study and the results show that they do not have statistical relationship with the dependent variable.

Personal characteristics

The average age of the producers surveyed was 64.2 years; 87% have on average 3.3 people who depend economically on them, which are made up mainly by the elderly. Of the total of farmers, 25% did not finish any school grade; 38% did not conclude Primary school. In this study, none of these variables had statistical relationship with the variable of study.

Other variables of analysis

Three variables were studied, the first being the attachment of farmers to customs around native corn. The entire population (100%) of the sample identified customs; 80% mentioned that they are related with regional foods of daily and festive consumption. For example, in the municipality of Altzayanca there is a pink corn named Xinaztle, which is used to make *atole* that according to the inhabitants, tastes like strawberry. Another custom was to take the seeds of native corn to be blessed on San Isidro day in order to have a good harvest. They mentioned that they do not take hybrid seeds. In San Juan Ixtenco, they elaborate a sour *atole* with black corn. Concerning this last municipality, in a study carried out by San Germán *et al*. (2020), the authors state that the relationship there is between the population and corn is close thanks to matters of religious tradition and spirituality. Of all the producers, only 32.63% said that they feel rootedness. This independent variable did not have a statistical relationship with the dependent variable.

Another variable of study was the knowledge that producers have about the work carried out by Universidad Autónoma Chapingo, Colegio de Postgraduados and INIFAP to obtain improved corn seeds. The statistical analysis showed that there was no relation with the variable of study. It could be detected that producers do not know this work by the institutions. In a study carried out in the central region of the country by Sánchez *et al.* (2016), the authors mention that there are different actors who participate in the transmission of innovations, although their main source are rural agribusinesses; and the greatest trend is to make consultations amongst themselves regarding the innovations. They signal that teaching and research institutions have the potential to be one of the main sources of knowledge for farmers; unfortunately, there are few that carry out extension work. In this sense, it should be highlighted that CEVAMEX INIFAP has trained seed producers and contributed to the formation of rural seed companies (García-Rodríguez *et al*., 2021; Larqué *et al.,* 2017).

Another independent variable was "knowing the hybrid corn seeds", and for this variable the results showed that there is a statistical relationship with the independent variable. The interpretation is: a producer who knows the hybrid corn seeds increases by 13.94 his willingness to sow them, compared to a producer who does not know them.

Of the total variables studied, only two had a statistical relationship with the variable of study. The variables sale of more than 50% of the corn grain (Sell > 50%) and knows the hybrid corn seeds (Knows H), have a $p < 0.05$ which indicates that they are different from zero (Table 4).

Native seeds that producers sow and reasons that support their preference

Of the farmers from the sample, 75% sow only local corn, 19% sow both hybrid and local. Of the total sowing local corn, 74.4% said that they have been sowing the same native seed from their locality or other localities in the state of Tlaxcala for more than 30 years; 18% said that their seeds are from the states of Puebla, Estado de México, Guerrero and Hidalgo. According to Louette and Smale (cited by Herrera *et al.,* 2002), the seeds considered "Creole" are those that are reproduced in the region since at least 30 years ago, so they are well-adapted to the conditions of the place.

Producers were asked why they prefer sowing local corn seeds and their response was: they grow with scarce water, even in dry times. In a study carried out by Orozco *et al*. (2019), the authors state that in 39 municipalities of the state of Tlaxcala, corn producers have adopted sowing local corn as strategy to face them as a way to face the droughts that have taken place in the state as consequence of climate change. Other reasons that explain their preference for these corn races were that they do not need many chemicals and they grow without them, and also that they are of short cycle; the tortillas and cobs taste better; the tortillas last longer and do not break because they need less lime for the *nixtamalization* process; the local corn does not generate cancer; cattle eat the stubble well; the ensilage is better than with the hybrid.

The local corn seeds that they sow are: *amarillo criollo, blanco criollo, negro criollo, blanco cremoso, azul chalqueño, rosa, maíz ancho, cacahuacintle, diente de mula, ochenteño, cabeza*

Table 4. Maximum likelihood analysis.

Parameter	DF	Estimate	Standar Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-3.2012	0.5952	28.9315	>.0001
p8	1	1.6763	0.6015	7.7660	0.0053
p19	1	2.63.49	0.6377	17.0742	<.0001

Odds Ratio Estimates			
Effect	Point Estimate	95 % Wald Confidence Limits	
p8	5.346	1.644	17.378
p19	13.942	3.995	48.655

de gorrión, xinastle, xocoyule, pinto, rojo, azul, sangre de cristo, morado, pata de paloma, cabeza de gorrión, ocho carreras, tablita.

Hybrid seeds that producers have sown and reasons why they stopped sowing them

Of the total farmers from the sample, 39% have sown hybrid corn seeds, 25% have sown them up to four times; of these, 19% sow local and hybrid seeds and 6% sow only hybrid. The farmers that stopped sowing hybrid seeds cited the following as causes: because they do not rent lands anymore, because they do not sell corn, because they sow for consumption by the family and livestock, because the grain is too hard, because the livestock do not eat the stubble; because they do not find the seed easily, because the seed is very expensive; because the seed is only good for one cycle and then degrades with time.

The seeds that have been sown are: Búho, Z-60, Campeón, AS722, AS723 and AS760 from Aspros; Faisán, Halcón, Gavilán, SB-300, SBA-470 from Berentsen; V23, H-33, H40, H48, H70 from INIFAP. Until the year 2015, the seeds that were more well-known among producers were Campeón and the seeds from INIFAP. Of the farmers from the sample, 39% have sown the seed Campeón at least once and 26% seeds from INIFAP at least once.

CONCLUSIONS

Of the total farmers from the sample, 75.7% said that they do not like sowing hybrid corn seeds and 24.3% said that they do like it. The characteristics of the producers that are related to their answer, I do like it, were two: they sell more than 50% of their harvest and they know the hybrid corn seeds. From the total of the sample of producers, only 27% sell more than 50% of their harvest. From the total of producers who work with hybrid corn, only 9% sow their lands with 100% of hybrid seeds; 100% of the producers who sow hybrid corn destine it to sales. In 2015, 39% of the farmers had sown at least once the hybrid corn seeds; 25% have sown it in four cycles (S-S). Several of the farmers who had sown the seed up to 2014 said that it was because they had received it as promotion, but not because they had purchased it with the goal of elevating their yields.

There is an inverse relationship between the number of farmers who sow hybrid corn seeds and the number of years of sowing; with more years, less farmers.

The transference work carried out by INIFAP and transnational companies in the municipalities of the state of Tlaxcala studied here has allowed for farmers to know these seeds, which influences their willingness to sow them, but not their decision to adopt them. In this study, it was defined that adoption of the seed takes place when the producer makes the decision of purchasing it to sow it.

REFERENCES

Aguilar Cordero WJ. 2008. Toma de decisiones en la elección y adopción de opciones productivas en unidades domésticas de dos grupos de productores campesinos del Municipio de Hocabá, Yucatán, México. Tesis de doctorado. Universidad Autónoma de Yucatán (UADY), Mérida, Yucatán. Recuperado el 18 de marzo de 2020, de http://www.eumed.net/tesis-doctorales/2008/wjac/index.htm.

AMSDA (Asociación Mexicana de Secretarios de Desarrollo Agropecuario). Sin fecha. Diagnóstico Sistema Producto Maíz Estado de Tlaxcala. Recuperado el 12 de junio de 2016. http://www.amsda.com.mx/PREstatales/Estatales/TLAXCALA/PREmaiz.pdf https://docplayer.es/7851366-Diagnostico-sistema-producto-maiz-estado-de-tlaxcala.html

Artís EG. Sin Fecha. Minifundio y fraccionamiento de la tierra ejidal parcelada. Estudios Agrarios. 21pp. Disponible en: http://www.pa.gob.mx/publica/cd_estudios/Paginas/autores/artis%20espriu%20gloria%20minifundio%20y%20fraccionamiento.pdf Consultado: 06/07/2016

Barillas SM. 2010. Producción de Semilla Certificada en el estado de Tlaxcala. Fundación Produce Tlaxcala A. C. 43 pp. Disponible en: http://www.siac.org.mx/fichas/36%20Tlaxcala%20Maiz.pdf https://1library.co/document/z1dxx1w8-fundaci%C3%B3n-produce-tlaxcala-a-c-p-e-%C3%A9.html Consultado: 08/10/2016

Byerlee D, Hesse de PE. 1982. La tasa y la Secuencia de Adopción de Tecnologías Cerealeras Mejoradas: El caso de la Cebada de Secano en el Altiplano Mexicano. Documento de trabajo de economía 82/6. CIMMYT. Recuperado el 15 de abril de 2021 de: http://repository.cimmyt.org:8080/xmlui/bitstream/handle/10883/999/6948.pdf?sequence=1andisAllowed=y

Cáceres D, Silvetti G, Rebolledo W. 1997. La Adopción tecnológica en sistemas agropecuarios de pequeños productores. Agro sur, 25 (2), Recuperado el 1 de marzo de 2020, de http://revistas.uach.cl/html/agrosur/v25n2/body/art01.htm

Cadena-Íñiguez P, Guevara HF, Arguello ARA, Rendón-Medel R. (mayo-junio, 2018). Ensayo. Proceso de comunicación, extensionismo y adopción de tecnología. [Versión electrónica] Revista Mexicana de Ciencias Agrícolas. 9 (4), 16 de mayo - 29 de junio. 851 – 864.

CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo) y SADER (Secretaría de Agricultura y Desarrollo Rural). 2019. MasAgro. Descripción General. Disponible en: https://masagro.mx/es/que-es-masagro/descripcion-general). Consultado el 07-05-2020

CIMMYT (Centro Internacional de Mejoramiento de Maíz y Trigo). 2019. Colaboración entre SADER y Centro Internacional de Mejoramiento de Maíz y Trigo brinda soluciones a productores. Disponible en: https://masagro.mx/es/component/content/article/41-boletines/boletines-2019/173-colaboracion-entre-sader-y-centro-internacional-de-mejoramiento-de-maiz-y-trigo-brinda-soluciones-a-productores Consultado 07-05-2020

CONAPO (Consejo Nacional de Población). Sin Fecha a. Cap. 1. Concepto y dimensiones de la marginación. Índice absoluto de marginación 2000-2010. pp. 11-15. Recuperado de: http://www.conapo.gob.mx/work/models/CONAPO/Resource/1755/1/images/01Capitulo.pdf. Consultado: 2/12/2018

CONAPO (Consejo Nacional de Población). Sin Fecha b. Índice de marginación por entidad federativa y municipio. Capítulo 1. El concepto y las dimensiones de la marginación. pp. 11-15. Recuperado de https://www.gob.mx/cms/uploads/attachment/file/159052/01_Capitulo_1.pdf. Consultado: 2/12/2018

CONASAMI (Comisión Nacional de Salarios Mínimos). 2015. Disponible en: http://www.conasami.gob.mx/boletin_nvos_sal_abril_2015.html Consultado 12-02-2020.

Damián HMÁ, Ramírez VB, Parra IF, Paredes SJA, Gil MA, López OJF, Cruz LA. (julio-septiembre, 2007). La especialización agrícola de los Distritos de Desarrollo Rural del Estado de Tlaxcala. [Versión electrónica] Revista de Geografía Agrícola, (39), 67-80.

Donnet L, López D, Arista J, Carrión F, Hernández V, González A. 2012. El potencial de mercado de semillas mejoradas de maíz en México. Documento de trabajo 8. CIMMYT. Recuperado el 20 de agosto de 2020 de: https://repository.cimmyt.org/xmlui/bitstream/handle/10883/1365/97506.pdf.

García-Rodríguez JJ, Gámez-Vázquez AJ, Gámez-Vázquez FP, Rangel-Fajardo MA, Mandujano-Bueno A, Ávila-Perches MÁ. 2021. Antecedentes y perspectivas de la tecnología y producción de semillas en el INIFAP. Revista Mexicana de Ciencias Agrícolas. Publicación especial número 25. 01 de junio -15 de julio. Pp. 33-43. Disponible en http://cienciasagricolas.inifap.gob.mx/index.php/agricolas/article/view/2813/4548. Consultado 18/12/202.

García-Salazar JA, Ramírez-Jaspeado R. 2013. El tamaño de las unidades de producción de maíz (*Zea mays* L.): un desafío para elevar la tasa de utilización de semilla mejorada. AGROCIENCIA, 47(8), 837 – 849.

García-Salazar JA, Ramírez-Jaspeado R. 2014. El mercado de la semilla mejorada de maíz (*Zea mays* L.) en México: análisis del saldo comercial por entidad federativa. Rev. Fitotec. Mex., 37(1), 69-77. Recuperado de http://www.scielo.org.mx/scielo.php?script=sci_abstractandpid=S0187-73802014000100010andlng=esandnrm=iso

Herrera CE, Macías-López A, Díaz RR, Valadez RM, Delgado VA. 2002. Uso de semillas criollas y caracteres

de mazorcas para la selección de semillas de maíz en México. Revista Fitotecnia en México. 25(1), enero-marzo, 17-23pp.

INEGI (Instituto Nacional de Estadística, Geografía e Informática). Sin Fecha. Aspectos Geográficos Tlaxcala. Recuperado el 30 de noviembre del 2021. https://www.inegi.org.mx/contenidos/app/areasgeograficas/resumen/resumen_29.pdf

Larqué-Saavedra BS, Uzcanga PN, Pérez del ÁAL, Sangerman-Jarquín DM, Islas GF, Rojas MI. 2017. Experiencias de los productores de semillas de maíz híbrido del INIFAP en el mercado de Tlaxcala. Revista Mexicana de Ciencias Agrícolas, 8(7), 1469-1482.

Lazos Chaveros E. 2014. Consideraciones socioeconómicas y culturales en la controvertida introducción del maíz transgénico: el caso de Tlaxcala. Sociológica (Méx.) 29(83). Ciudad de México sep./dic. Versión On line. Disponible en: http://www.scielo.org.mx/scielo.php?pid=S0187-01732014000300006andscript=sci_abstract Consultado: 12/12/2021

Montesinos-López OA, Luna EI, Hernández SCM, Tinoco ZMA. 2009. Muestreo estadístico. Tamaño de muestra y estimación de parámetros. Universidad de Colima. Recuperado el: 4 de marzo de 2014. https://www.researchgate.net/publication/287490384_Muestreo_Estadistico_Tamano_de_muestra_y_estimacion_de_parametros/link/5d785291299bf1cb80981a1f/download. Consultado 4/03/2014

Noriero EL, Massieu TY. 2018. Campesinos maiceros en Tlaxcala: viabilidad, caracterización y respuestas ante el maíz transgénico. Soc. ambient. no.16 versión On-line Lerma Campeche. Marzo. Disponible en: http://www.scielo.org.mx/scielo.php?pid=S2007-65762018000100179andscript=sci_arttext Consultado 11/12/2021

Orozco BH, Hernández VM, García JG, Suárez GG. 2019. Cambio climático: una percepción de los productores de maíz de temporal en el estado de Tlaxcala, México. Revista Iberoamericana de Ciencias Biológicas y Agropecuarias. 10(19). julio-diciembre. Disponible en: https://www.ciba.org.mx/index.php/CIBA/article/view/89/381 Consultado 23/11/2021 https://www.redalyc.org/articulo.oa?id=33913144005

Orozco CS, Ramírez VB, Ariza FR, Jiménez SL, Estrella ChN, Peña OBV, Ramos SÁ, Morales GM. agosto, 2009. Impacto del conocimiento tecnológico sobre la adopción de tecnología agrícola en campesinos indígenas de México. [Versión electrónica] Interciencia 34(8), 551 - 555.

Pérez-Sánchez A, Hernández-Cortés C, Carmona-Silva JL. 2017. Estrategias de maíz de los hogares campesinos en el municipio de Atlangatepec, Tlaxcala. Agricultura Sociedad y Desarrollo, 14(1). Texcoco ene./mar. 2017. Disponible en: http://www.scielo.org.mx/scielo.php?script=sci_arttextandpid=S1870-54722017000100001 Consultado: 2/12/2021

Pérez Sánchez A, Hernández Cortés C. 2019. Territorio y estrategias alimentarias de hogares campesinos en Tlaxcala, México. Volumen 11 – Número 22. Disponible en: http://revistanupem.unespar.edu.br/index.php/nupem/article/view/604 Consultado: 11/12/2021

SAGARPA (Secretaría de Agricultura Ganadería, Desarrollo Rural, Pesca y Alimentación). 2014. Descripción de PIMAF. Disponible en: http://www.sagarpa.gob.mx/ProgramasSAGARPA/2014/fomento_agricultura/PIMAF/Paginas/Descripci%C3%B3n.aspx. Consultado: Consultado 12-07-2018

Sagastume N, Rodríguez R, Obando M, Sosa H, Fishler M. Junio 2006. Guía para elaboración de estudios de adopción de tecnologías de manejo sostenible de suelos y agua. Documento No. 499 Serie Técnica 7/2006. Programa para la Agricultura Sostenible en Laderas de América Central (PASOLAC), Intercooperation, COSUDE. 29 pp. https://es.scribd.com/document/346572729/Guia-de-Adopcion-de-Tecnologias Consultado el 14/01/2016

San Germán-Jarquín DM, De la O-O M, Gámez VAJ, Navarro BA, Ávila PMA, Schwentesius RR. 2020. Etnografía y prevalencia de maíces nativos en San Juan Ixtenco, Tlaxcala, con énfasis en maíz ajo (*Zea mays* var. tunicata A. St. Hil.). Rev. fitotec. mex vol.41 no.4 Chapingo. Epub 30-Sep. Disponible en: http://www.scielo.org.mx/scielo.php?pid=S0187-73802018000400451andscript=sci_arttext Consultado: 20/12/2021

Sánchez GJ, Rendón MR, Díaz JJ. 2016. Sonder K. El soporte institucional en la adopción de innovaciones del productor de maíz: región centro, México. Revista Mexicana Cienciencias Agrícolas, 7(núm especial 15). Texcoco. jun./ago 2016 Disponible en: http://www.scielo.org.mx/scielo.php?script=sci_arttextandpid=S2007-09342016001102925andlng=esandnrm=isoandtlng=es

SIAP (Servicio de Información Agroalimentaria y Pesquera). Sin Fecha. Avances de siembra y cosechas. Resumen por estado. 2015. Recuperado el 18 de octubre de 2018. http://infosiap.siap.gob.mx:8080/agricola_siap_gobmx/ResumenProducto.do

SIAP (Servicio de Información Agroalimentaria y Pesquera). 2021. Resumen de siembras y cosechas. Resumen

por cultivo. Recuperado el 18 de octubre del 2016. http://infosiap.siap.gob.mx:8080/agricola_siap_gobmx/ResumenDelegacion.do

Sistema - Producto Maíz. Estado de Tlaxcala. Sin Fecha. Diagnóstico del Sistema Producto Maíz. Pp. 3 – 37. Disponible en: https://docplayer.es/7851366-Diagnostico-sistema-producto-maiz-estado-de-tlaxcala.html

Velázquez LJ, Juárez SJP, Ramírez-Valverde B, Jiménez MJ, Taboada GOR, Del Valle SM. 2019. Adopción de tecnología agrícola y su influencia en la productividad y competitividad del maíz en el centro-oriente del estado de Puebla, México. Revista Geografía Agrícola (63), 101-119. http://www.cedrssa.gob.mx/files/10/32Evoluci%C3%B3n%20del%20PIMAF.pdf pag. 9 http://www.cedrssa.gob.mx/files/b/13/93Las_semillas_en_M%C3%A9xico_-_agosto_2015.pdf