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Artículos Científicos

Cambio climático: Una percepción de los productores de maíz de temporal en el estado de Tlaxcala, México

Climate Change: A Perception of Maize Producers of the State of Tlaxcala, México

Mudança climática: uma percepção dos produtores sazonais de milho no estado de Tlaxcala, México

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Resumen

La actividad agrícola en el estado de Tlaxcala depende en gran medida del clima. El productor de maíz se encuentra inmerso en esta contingencia: lo percibe de forma positiva o negativa dependiendo de los sucesos que se presenten. El objetivo fue determinar la percepción y caracterizar los saberes que tienen acerca del clima, el impacto del cambio climático en la producción y la capacidad adaptativa del maíz. La investigación fue de tipo descriptivo-analítico. La población de estudio fueron productores de maíz criollo bajo condiciones de temporal. Se tomó una muestra no probabilística de tipo incidental. La técnica fue la encuesta: se aplicaron 1930 cuestionarios en 39 municipios del estado de Tlaxcala. Los principales hallazgos fueron que 78 % de los productores son mayores de 50 años de edad y 60 % cuenta con educación primaria. La sequía y las heladas son los principales eventos del clima que han impactado al cultivo y han ocasionado pérdidas y bajos rendimientos. Las estrategias que han adoptado ante las variaciones del clima son el cambio en las fechas de siembra, selección de semilla nativa resistente a la sequía y uso de abonos orgánicos para minimizar los efectos del clima. La percepción de los entrevistados estuvo significativamente correlacionada ($p \geq 0.05$). Los conocimientos y saberes del clima y la semilla que posee el agricultor están en peligro, por lo tanto, la seguridad alimentaria se ve amenazada por los efectos del cambio climático en la producción de maíz de temporal.

Palabras clave: cambio climático, maíz, percepción, productor.

Abstract

Agricultural activities in the state of Tlaxcala rely mostly on climate conditions. Corn producers know this and adopt a positive or negative perspective according to the way they are present each year. The aim of this work was to determine the producers´ perspective and the characterization of knowledge that they possess about weather, climate change impact on production and the adaptability of corn. This research was descriptive-analytical type. The target subject were Creole corn producers under rainfed conditions. It was taken a probabilistic, incidental sample. The used technique was the survey, applying 1930 questionnaires in 39 municipalities in Tlaxcala. From this, it was obtained that 78% of the interviewed producers are over 50 years old, and 60% reached primary school education. Drought and frost are the main climate events that have an impact on their crops resulting in low production as well as a great economical lost. Corn producers have developed several strategies due to these climate variations, some of them are: changing planting dates, using native seeds resistant to drought, and using organic fertilizers to reduce climatic effects. The interviewed producers´ perception was considerably correlated ($p \geq .05$). It can be perceived from this that the knowledge related to weather conditions and the seeds that farmers have, both are endangered; therefore, food security is threatened due to climatic changes that affect water-fed corn production.

Keywords: climatic change, corn, perception, producer.

Resumo

A atividade agrícola no estado de Tlaxcala depende em grande parte do clima. O produtor de milho está imerso nessa contingência: ele percebe isso de forma positiva ou negativa, dependendo dos eventos que ocorrem. O objetivo foi determinar a percepção e caracterizar o conhecimento que possuem sobre o clima, o impacto das mudanças climáticas na produção e a capacidade adaptativa do milho. A investigação foi descritivo-analítica. A população do estudo foi produtores de milho crioulo em condições de sequeiro. Uma amostra não probabilística do tipo incidental foi tomada. A técnica foi a pesquisa: 1930 questionários foram aplicados em 39 municípios do estado de Tlaxcala. As principais conclusões foram que 78% dos produtores têm mais de 50 anos de idade e 60% têm educação primária. A seca e a geada são os principais eventos climáticos que afetaram a safra e causaram perdas e baixos rendimentos. As estratégias adotadas frente às variações climáticas são a mudança nas datas de semeadura, a seleção de sementes nativas resistentes à seca e o uso de fertilizantes orgânicos para minimizar os efeitos do clima. A percepção dos entrevistados foi significativamente correlacionada ($p \geq 0,05$). O conhecimento e conhecimento do clima e da semente que o agricultor tem está em perigo, portanto, a segurança alimentar está ameaçada pelos efeitos das mudanças climáticas na produção de milho de sequeiro.

Palavras-chave: mudança climática, milho, percepção, produtor.

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Introduction

Agriculture is the activity in which man, in a given environment, manages natural resources, the quality and quantity of available energy and the means of information to produce and reproduce the vegetables that meet their needs. It started based on a gradual accumulation of ecological and biological knowledge about the natural resources used; it was developed through indigenous systems of generation and transmission of said knowledge, of adaptation and adoption of technological innovations in several regions of the world, among them Mexico (Hernández, 1988).

In our country, agricultural activity is very important in rural areas as a source of income and as a provider of food, which depends on the available natural resources (Food and Agriculture Organization of the United Nations [FAO] -Secretariat of Agriculture and Rural Development [SAGARPA], 2012), and climate elements such as temperature and rainfall (Altieri and Nicholls 2009, Hernández, Jiménez, García, Jiménez Orozco, Hernández and Morales 2015), especially in rainfed agriculture. In this sense, it is important to note that the planet earth, naturally and because of anthropogenic activities, has presented changes in the climate over the years, which has resulted in what is now called global warming. This threatens the production of food (Rubio, 2011) through heat waves, droughts, floods, frosts, hailstorms and cyclones, exposing different systems such as ecological and human (Count, Ferrer, Gay and Araujo, 2004; Meza, 2014, Intergovernmental Panel on Climate Change [IPCC], 2014). There are three main impacts of climate change on agriculture: a) deterioration in crop yields; b) effects on production, consumption and marketing, and c) effects on caloric consumption per capita and child nutrition (FAO y SAGARPA, 2012; Nelson *et al*., 2009, citados en Meza, 2014; Appendini, 2008; Hernández, García, Orozco y Juárez, 2018).

In Mexico, the most important crop is corn, which will be seriously impacted by the already mentioned climate change in the reduction of potential areas for its production (Hernández et al., 2018). Faced with this scenario, a determining character is the farmer, who has knowledge and knowledge of when to plant and what seed to use to deal with the losses that threaten the yields necessary for self-consumption. Among other problems they face are the increase of pests and diseases, which causes negative impacts on their income and food security in peasant families (FAO and SAGARPA, 2012). Research on the subject of perception of climate change on corn is scarce (Vásquez, 2016, Ahumada, Velázquez, Flores, and Romero, 2014); there are works carried out in the indigenous population and agricultural communities (Barsky, Podestá and Ruiz, 2008, Vander, 2011, Pinilla, Sánchez, Rueda and Pinzón, 2012, Espinoza et al., 2012, Solís and

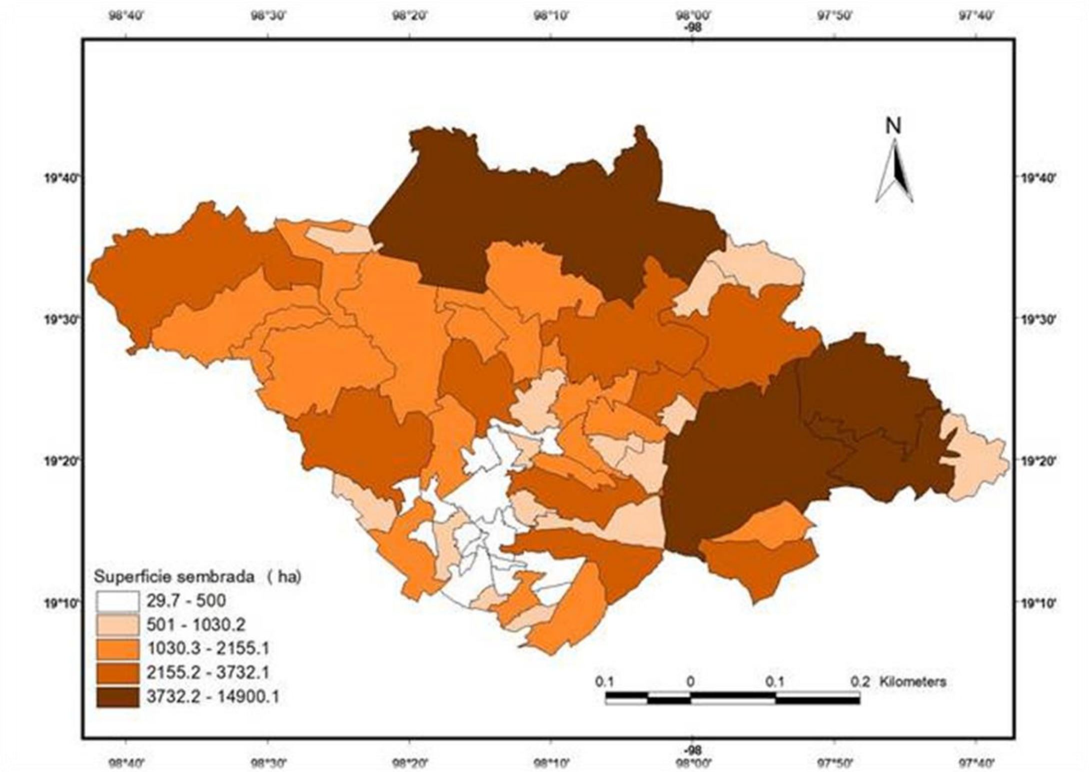
Salvatierra 2013, González et al., 2017), and others more oriented to the population in general (Oltra, Solá, Sala, Prades and Gamero, 2009, Soares and Gutiérrez 2011, Olmos, Gonzales and Contreras, 2013, Ahumada and García, 2018). Consequently, this research focuses on the perception of the seasonal corn producer, who faces challenges when carrying out their work, and applies the acquired empirical knowledge as strategies to mitigate the effects of climate change and food security.

Method

Study Area

This investigation is descriptive-analytical. To select the study area, we proceeded to regionalize the state of Tlaxcala with data from the planted area destined to the cultivation of corn in the temporal mode. (Sistema de Información Agroalimentaria y Pesquera [SIAP], 2018).

Figura 1. Regionalización de la superficie sembrada de maíz del estado de Tlaxcala



Fuente: Elaboración propia con datos del SIAP (2018)

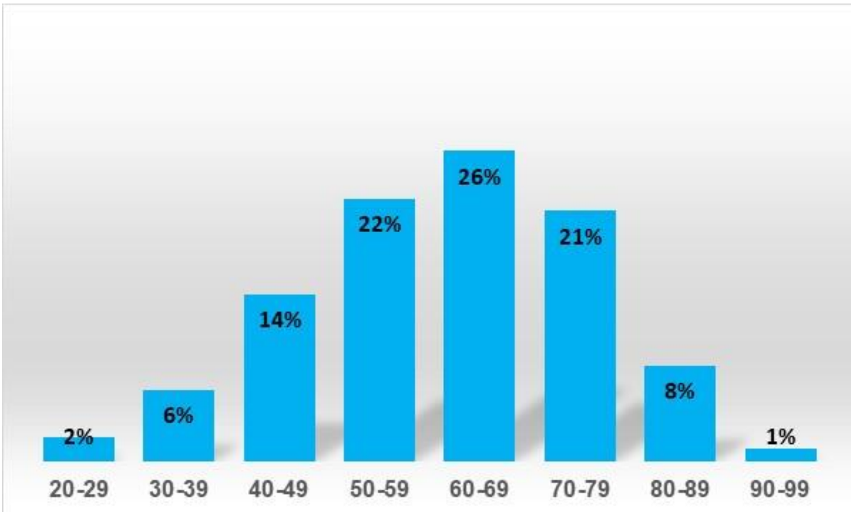
The municipalities that made up the study area were 39 out of 60. An inclusion criterion was to choose those that had more than 500 hectares planted with corn (figure 1). The study population was made up of corn producers in rainy season conditions. The database was obtained from the Program of Direct Field Supports [Procampo] (2016). In total there were 26,371. Of these, 1939 were interviewed. The technique was the survey, the sampling was incidental (Garriga et al., 2015). A questionnaire was designed taking up questions related to the cultivation of maize by Orozco, García, Hernández and Juárez (2016). Likewise, reagents related to climate change were prepared and incorporated. The questionnaire was organized in four sections: I. General data, II. Climate change and maize, III. Characteristics and variables in the cultivation of corn and IV. Maizes that have been lost. The answers were multiple choice and open. It should be noted that a pilot test was carried out to validate it. The data obtained through the application of the questionnaire were subjected to descriptive statistics to analyze the trends of the data. A Pearson test was also carried out with the SPSS Version 21 software to determine if there was a correlation between regions regarding the perception of corn producers in relation to climate change.

Results

General Data

The producers interviewed who dedicate themselves to the cultivation of seasonal corn have an average age of 61 years; 78% are in the ranges of 50 to 99 (Figure 2). This indicates that the population is of advanced age, young people are not integrating into the countryside. The tendency of this situation puts at risk not satisfying the demand for human consumption.

Figura 2. Edad de los productores de maíz del estado de Tlaxcala



Fuente: Elaboración propia

Corn production

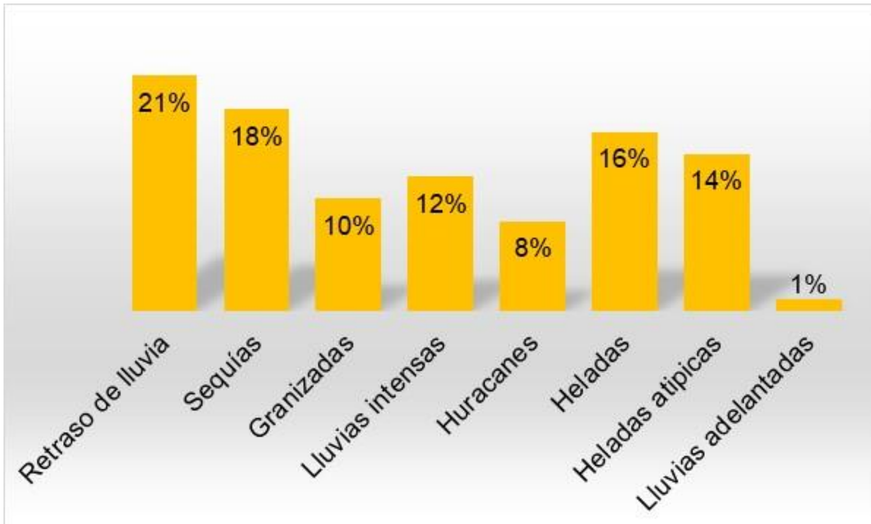
In the state, the main type of corn sown by the producer is white (55%), blue (15%), yellow (14%), sangre de Cristo (1%) and others such as cañuela, rojo rojo, pepitilla , moradilla, cacahuacentle and improved (15%). On average, the area sown is 5.8 ha, with a yield of 2.9 tons / ha. The main destination of its harvest is the sale (63%), for animal feed (25%), for human consumption (11%) and to be saved to stop the next agricultural cycle (1%), with this the seed is maintained in germplasm banks in situ.

Manifestations of the climate

In the opinion of the producers, the signs of climate change that occur in their community are shown in figure 3, highlighting the delay of rains (21%), prolonged droughts (18%) and frosts

(16%). Undoubtedly these main problems observed are the result of the effects of climate change, and threaten production in agricultural systems.

Figura 3. Señales del cambio de clima en localidades del estado de Tlaxcala



Fuente: Elaboración propia

Presence of extreme weather events

When analyzing the climatic events and the months in which they occur, changes can be observed according to the opinion of the producer, for example, the delay of rains has traveled to May and June. The droughts have extended to May, June and July. The month with the highest number of hailstorms is August, although they can also be presented in June, July and September. Frosts are present as of the month of September (figure 4). Faced with this situation, the corn producer is frequently threatened, because the agricultural cycle of rainfed season has been modified by this climate variability.

Figura 4. Presencia de los principales eventos climáticos extremos

Fuente: Elaboración propia

Frequency of climatic events

Figure 5 shows the climatic events that most affect corn yield. It is observed that the drought is the most frequent with 40%, followed by frost with 30%. It is clear that the problem is drought. This phenomenon is a tendency of the climatic change that indicates the reduction of rains and the increase of temperature, and makes the production of corn vulnerable.

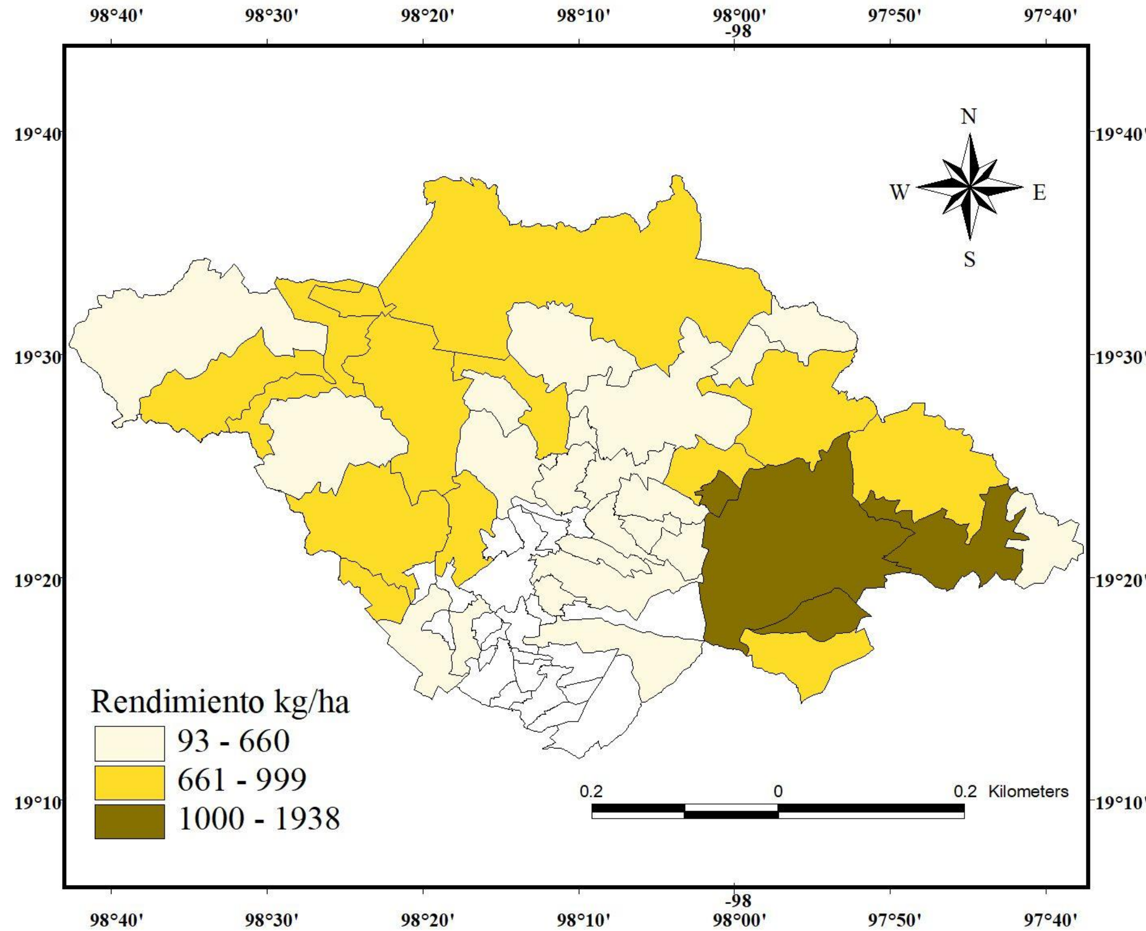
Figura 5. Frecuencia de los eventos climáticos que afectan el rendimiento del cultivo de maíz

Fuente: Elaboración propia

Corn yield

Figure 6 shows the yield of corn reported by producers when drought or frost occurs. Of 39 municipalities, 56% of them are the most vulnerable to climatic variations, obtaining a production that goes from 93 to 660 kg / ha; Apizaco, Nanacamilpa, Ixtacuixtla, Altzayanca, Xaltocan, Contla, Panotla, Tzompantepec, Tetlanohcan, Muñoz, Teacalco, Teolocholco, Tlaltelulco, Lázaro Cárdenas, Zitlaltepec, Zapata, Yauhquemehcan, Xaloztoc, Tocatlán, Tlaxco, Tetlatlahuca and Tetla are some of them. And while these are the ones that presented the lowest yields, the rest of the localities are also affected. The foregoing makes evident the risk in which food security is found for peasant families when they see municipalities that are having negative effects on corn production.

Figura 6. Impactos del cambio climático en el rendimiento de maíz



Fuente: Elaboración propia

Adaptation strategies

Table 1 shows by municipality the strategies adopted by farmers to continue planting maize in the face of climatic variations. In general, 28% have made changes in sowing dates and selection of native seeds resistant especially to drought, followed by organic fertilizer with 26%. These are the main strategies that are applied in all municipalities. Which speaks of the producer is worried about the climatic eventualities, especially the drought, and looks for alternatives to continue producing. It is important to note that the characteristics to select the seed are the following: the size of the grain, which has no pest and which is clean. Another strategy is the application of organic fertilizer because, when applied, the soil is enriched and the plant resists, there is greater moisture retention and the presence of pests is reduced.

Tabla 1. Estrategias de adaptación ante el cambio climático

Municipio	Cambio en fechas %	Semilla nativa %	Abono orgánico %	Barreras naturales %	Variedades mejoradas %	Jagüeyes %
Altzayanca	30	25	28	7	5	4
Apizaco	27	25	25	14	9	0
Atlangatepec	28	28	25	10	2	6
Benito Juárez	28	26	24	13	6	3
Calpulalpan	27	8	23	17	21	3
Chiautempan	29	31	26	12	2	0
Coaxomulco	29	32	27	9	2	1
Contla	23	33	33	11	0	0
Cuapiaxtla	32	27	26	4	8	2
El Carmen	29	31	30	0	7	3
Españita	28	29	26	9	2	5
Huamantla	32	27	28	9	1	3
Hueyotlipan	26	26	24	11	5	7
Ixtacuixtla	28	28	27	1	15	1
Ixtenco	30	29	27	2	7	4
Lázaro Cárdenas	28	28	26	10	6	1
Magdalena	28	32	30	9	1	0
Muñoz	30	23	25	9	12	0
Nanacamilpa	27	24	23	11	14	0
Nativitas	28	30	27	7	7	1
Panotla	31	31	25	5	7	0
Sanctorum	27	25	21	15	9	2
Santa Cruz	30	33	29	8	0	0
Teacalco	25	33	27	13	0	1
Tecopilco	28	25	26	13	6	1
Teolocholco	28	31	28	11	1	0
Tepetitla	29	30	29	5	6	0
Terrenate	29	26	22	10	9	3
Tetla	27	28	24	9	7	5
Tetlanhocan	25	31	30	11	2	0
Tetlatlahuca	27	30	29	6	8	0
Tlaxco	31	27	25	13	1	2
Tocatlán	28	30	26	9	5	2
Tzompantepec	30	27	30	9	4	0
Xaloztoc	28	31	27	9	3	1
Xaltocan	31	31	27	8	2	0
Yauhquemecan	30	27	27	10	5	0
Zapata	22	34	26	9	4	4
Zitlaltepec	28	32	27	11	0	2
TOTAL	**28%**	**28%**	**26%**	**9%**	**6%**	**2%**

Fuente: Elaboración propia

Perception of climate change

In relation to the perception of the producers, in table 2 the correlation in the regions of analysis is presented. A significant correlation was found in all cases ($p \geq 0.05$) with values close to one. Therefore, it was evidenced that the effects of climate change have been perceived in a similar way by corn producers in the different municipalities. Finally, they point out that the years in which they noticed a radical change in the climate of their locality have been in recent times; 76% of farmers agreed in the following years: 1997, 2000, 2002, 2007, 2010, 2011, 2012, 2014, 2015 y 2017.

Tabla 2. Percepción de productores en las regiones de análisis ante el cambio climático

		Región 1	**Región 2**	**Región 3**	**Región 4**	**Región 5**
Región 1	Correlación de Pearson	1	.935**	.912**	.908**	.921**
	Sig. (bilateral)		.000	.000	.000	.000
	Suma de cuadrados y productos cruzados	7591.053	7203.211	6266.947	6767.211	5953.211
	Covarianza	205.164	194.681	169.377	182.898	160.898
	N	38	38	38	38	38
Región 2	Correlación de Pearson	.935**	1	.937**	.887**	.921**
	Sig. (bilateral)	.000		.000	.000	.000
	Suma de cuadrados y productos cruzados	7203.211	7814.842	6534.789	6708.842	6042.842
	Covarianza	194.681	211.212	176.616	181.320	163.320
	N	38	38	38	38	38
Región 3	Correlación de Pearson	.912**	.937**	1	.935**	.877**
	Sig. (bilateral)	.000	.000		.000	.000
	Suma de cuadrados y productos cruzados	6266.947	6534.789	6221.053	6311.789	5135.789
	Covarianza	169.377	176.616	168.137	170.589	138.805
	N	38	38	38	38	38
Región 4	Correlación de Pearson	.908**	.887**	.935**	1	.893**
	Sig. (bilateral)	.000	.000	.000		.000

	Suma de cuadrados y productos cruzados	6767.211	6708.842	6311.789	7320.342	5670.842
	Covarianza	182.898	181.320	170.589	197.847	153.266
	N	38	38	38	38	38
Región 5	Correlación de Pearson	.921**	.921**	.877**	.893**	1
	Sig. (bilateral)	.000	.000	.000	.000	
	Suma de cuadrados y productos cruzados	5953.211	6042.842	5135.789	5670.842	5506.842
	Covarianza	160.898	163.320	138.805	153.266	148.834
	N	38	38	38	38	38

** La correlación es significativa al nivel 0.01 (bilateral)

Fuente: Elaboración propia

Discussion

Climate change is evidence of the increase in global temperature. And in recent years the agricultural sector has been one of the most affected by this type of alterations. The people who attend the field are not alien to these events. Maize producers perceive these changes in their localities, as they impact the crop. This statement is in line with what Conde et al. Points out. (2004) and Meza (2014): agriculture is highly sensitive or vulnerable to climatic variations; the production of seasonal corn is not the exception. For example, as pointed out by Araus, Slafer, Royo and Serret (2008), the lack of water at the precise moment of one of the stages of crop growth limits their productivity. Maize producers are key elements to minimize the impacts of climate change on production, because they know the seed and its environment. The experience and the observation have to do with the time they dedicate to the field, and this is related to age. As mentioned above, most are over 60 years old. In addition, the majority has only primary education, information similar to that presented by the Economic Commission for Latin America and the Caribbean [ECLAC] (2014). This fact is worrisome because the new generations are not entering the field (they migrate to work or study); then, the empirical knowledge and knowledge related to the climate of said activity is not transmitted, which puts the production of corn at risk. This undoubtedly poses a generational challenge over who will produce corn in the future and anticipates, perhaps, a larger scale dependence on transnational imports to feed us.

In Mexico, there are between 41 and 59 maize races (Reyes, Guerra and Calderón, 2005, Gil and Álvarez 2007, Fitting, 2007, Madrigal, 2008); for the state of Tlaxcala 12 races are reported (María, Hernández, Muñoz de la Vega and Ríos, 2015), which represents 24% nationwide. This refers to a genetic richness of Creole corn, differentiated by its color and shape (white, yellow, blue, red, black, pink, cream, purple, garlic), which has been preserved for years in situ in small storage banks (in a room with ventilation inside the house, or in zencales -constructions outside the home of approximately 1 mx 1 m, with ventilation-, in addition to the cuexcomates, among others), which the producer preserves when saving seeds in each agricultural cycle . This variability of germplasm is very important because, as indicated by Altieri and Nicholls (2009) and Cruz (2011), many of the rural communities dominated by traditional agriculture are preparing for climate change by minimizing crop losses through increased use of local varieties of corn seed tolerant to drought. FAO (2016) notes that agricultural performance after extreme weather events has shown that resilience to climate disasters is linked to the biological diversity of the regions. So, genetic wealth is an important element to mitigate the impacts of climate change. The challenge is to maintain this diversity; that is not replaced by transgenic corn (Madrigal, 2008).

The signs or manifestations of some climatic variables that have changed in the communities studied here are the increase in temperature, prolonged droughts, the presence of frost, lack of rain and hail. These results coincide with the research conducted by Barsky et al. (2008), Oltra et al. (2009), Soares and Gutiérrez (2011), Cruz (2011), Vander (2011), Pinilla et al. (2012), Espinoza et al. (2012), Solís and Salvatierra (2013), Olmos et al. (2013), González et al. (2017), Ahumada and García (2018) and Vásquez (2016), who also expose it as evidence of the climatic variability that is being presented, always in accordance with the perception of the population. In the case of Tlaxcala, it is worth highlighting, first, the prolonged droughts, the delay of rains and frosts, in second and third place respectively, climatic variables that, according to the IPCC (2015), are consequences of the recent extreme phenomena. related to climate, such as heat waves, droughts, floods, cyclones and forest fires, which highlight an important vulnerability and exposure of some ecosystems.

The above is related to climate variability over time, for example, rain now occurs in May and June, and, therefore, the drought extends to May, June and July. Hernández et al. (2015) predict that if the tendency of the rain is to reduce, then the periods of droughts will increase, but their spatial distribution will vary and therefore the impacts will be different from one place to another. Frosts occur from September and atypical frosts in any month of the year. These changes cause the agricultural calendar to be traversed. Castro (2006) compares these events in the municipality of Calpulalpan, Tlaxcala state, in two periods, 1920-1960 and 1960-2000: planting in the first period was carried out between April and May; in the second, between June and July.

The IPCC (2015) notes that the negative impacts of climate change on crop yields have been more common than the positive impacts. This is confirmed because in the case of the municipalities of Tlaxcala, 20 of them are the most vulnerable when reporting a production lower than the average obtained (which was 689 kg / ha) when there were accidents such as droughts and frosts. Data from the SIAP (2018) show that the production years of 1999, 2002, 2005 and 2011 were the most affected by climatic effects, which caused the yield to fall to 1.40, 1.69, 1.37, 1.64, respectively, well below the national average (2.5 ton / ha). This reaffirms once again the vulnerability of agroecosystems to climatic variations. Meza (2014) states that the temperature increase registered in the last 30 years has generated a decrease in the expected yield increase in wheat and corn. However, it can be said that even with climatic contingencies the farmer obtains production; fact that is determinant in food security. Therefore, the producer, to deal with these contingencies, implements alternatives or strategies to plant corn, such as the change in sowing dates and a selection of native seeds resistant to drought, according to Altieri and Nicholls (2009) and Barsky et al. to the. (2008). They also apply organic fertilizer and conserve the seed in situ, that is, adaptation to climate change (Meza, 2014).

Finally, this research confirms that, among the regions of analysis, the perception is similar in relation to the effects of climate change, and that in recent years the effects have been accentuated more. Evidently these have forced producers to implement various strategies to continue with the production of corn and, at the same time, conserve the germplasm of native seeds. Actions that have helped to ensure their availability. The latter a basic component of food security (Salcedo, 2005).

Conclusions

The seasonal corn producer is one of the main actors in agriculture and national food. However, in the municipalities of Tlaxcala studied here, food security is threatened because the production of seasonal corn is basically under the responsibility of older producers. They are the most important characters in mitigating the impact of climate change because they possess the knowledge and knowledge of the climate.

The biodiversity of the corn seed is a strength in the Tlaxcala field because it is adapted to the physical, geographical and biological conditions, characteristics that allow it to face the variations of the climate.

The most frequent extreme climatic events are the delay of rains, prolonged droughts and frosts, which have an impact on the yield of seasonal corn and represent a risk for self-consumption. Given these events, the perception is that there are changes in the climate of the locations already specified and that the effects have been more evident in recent years.

The alternatives to mitigate the effects of climate change on the production of seasonal maize are mainly the knowledge and knowledge of the producer, which has allowed him to implement various strategies to face the consequences of climate change through the use of native seed, change of dates of sowing and the application of organic fertilizer.

This approach with the corn producers of the state of Tlaxcala leaves very important lessons for the foregoing, this type of studies should be considered in the decision making process to implement interinstitutional public policies and programs oriented toward inclusive social justice; programs that comprehensively address the needs in the agricultural sector with an educational, economic, cultural, environmental, labor, among others, taking as an essential axis education with emphasis on techniques that can be used to face the adversities of climate change, as well as information that potentializes the creative capacities under the principles of sustainability, aimed at preserving the native seed species of corn and the ancestral knowledge and knowledge that the farmer possesses to strengthen food security and sovereignty in the localities and regions of the country.

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References

Ahumada, C. R., Velázquez, A. G., Flores, T. E. y Romero, G. J. (2014). Impactos potenciales del cambio climático en la producción de maíz. *Investigación y Ciencia, 22*(61), 48-53. Recuperado de http://www.redalyc.org/pdf/674/67431579007.pdf.

Ahumada, C. R. y García, L. P. (2018). Conocimiento y percepción acerca del cambio climático en comunidades costeras del municipio de Guasave, Sinaloa, México. *Investigación y Ciencia, 26*(75), 38-45. Recuperado de https://investigacion.uaa.mx/RevistaIyC/archivo/rev75.pdf.

Altieri, M. A. y Nicholls, C. I. (2009). Cambio climático y agricultura campesina: impactos y respuestas adaptativas. *Agroecología*, 5-8. Recuperado de http://socla.co/wp-content/uploads/2014/leisa-campesino-cambio-climatico.pdf.

Araus, J. L., Slafer, G. A., Royo, C. and Serret, M. (2008). Breeding for yield potential and stress adaptation in cereals. *Critical Reviews in Plant Science, 27*, 377-412.

Appendini, K., Cortés, L. y Hinojosa, V. (2008). Estrategias de seguridad alimentaria en los hogares campesinos: la importancia de la calidad del maíz y la tortilla. En Appendini, K. y Torres, G. (eds.), *Ruralidad sin Agricultura* (pp.103-127). Ciudad de México, México: Centro de Estudios Económicos, El Colegio de México.

Barsky, A., Podestá, G. y Ruiz, T. F. (2008). Percepción de la variabilidad climática, uso de información y estrategias de los agentes frente al riesgo. Análisis de esquemas decisionales en agricultores de la región pampeana Argentina. *Mundo Agrario, 8*(16), 1-42. Recuperado de http://www.redalyc.org/pdf/845/84581603.pdf.

Castro, F. 2006. *Colapsos ambientales-transiciones culturales.* México: Universidad Nacional Autónoma de México & Benemérita Universidad Autónoma de Puebla.

Comisión Económica para América Latina y el Caribe [CEPAL]. (2014). *Perspectivas de la agricultura y del desarrollo rural en las Américas: Una mirada hacia América Latina y el Caribe 2014.* San José, Costa Rica: Comisión Económica para América Latina y el Caribe, Organización de las Naciones Unidas para la Agricultura y la AlimentaciónInstituto Interamericano de Cooperación para la Agricultura.

Conde, C., Ferrer, R. M., Gay, C. y Araujo, R. (2004). Impactos del cambio climático en la agricultura en México. En Martínez, J. y Fernández, A. (coords.), *Cambio climático: Una visión desde México* (pp. 227-238). México: Semarnat-INE. Recuperado de http://www.data.sedema.cdmx.gob.mx/cambioclimaticocdmx/images/biblioteca_cc/Cambio-climatico-una-vision-desde-Mexico-(Julia-Martinez-y-Adrian-Fernandez-Bremauntz-compilado.pdf.

Cruz, L. M (2011). Comparación del ciclo agrícola actual con el de hace unos diez años en san Juan Jalpa municipio San Felipe del progreso estado de México: evidencia de adaptación al cambio climático. *Ra Ximhai*, *7*(1), 95-106. Recuperado de http://www.revistas.unam.mx/index.php/rxm/article/view/26670.

Espinoza, Y., Obispo, N., Gil, J., Rodríguez, M. F., Cortez, A., Rey, J. C., Parra, M. R., Espinoza, F. y Seijas, L. (2012). Percepción del cambio climático en la población rural La Guama, San Sebastián de los Reyes, Aragua Venezuela. *Facultad Agronomía*, *38*(3), 106-114. Recuperado de http://www.scielo.org.ar/scielo.php?script=sci_nlinks&ref=5910830&pid=S1666-77192016000200004000004&lng=es.

Fitting, E. (2007). ¿La economía natural enfrenta a la global? Desafíos a los debates sobre el maíz. *Bajo el Volcán*, *7*(11), 17-44. Recuperado de http://www.redalyc.org/articulo.oa?id=28671103.

Garriga, A. J., Lubin P. P., Merino J. M., Padilla S. M., Recio S. P. y Suárez, J. C. (2015). *Introducción al análisis de datos*. Madrid, España: Universidad Nacional de Educación a Distancia,

Gil, A. y Álvarez, N. M. (2007). *El maíz criollo en la alimentación de las familias campesinas de Santiago Xalitzintla, Puebla.* Puebla, México: Colegio de Postgraduados Campus Puebla.

González, L. L., Silva, J. T., Ávila, L. A., Moncayo, E. R., Cruz, C. G. y Ceja, L. F. (2017). El fenómeno de cambio climático en la percepción de la comunidad indígena purépecha del municipio de Chilchota, Michoacán, México. *Contaminación. Ambiental, 33*(4), 641-653. doi: 10.20937/RICA.2017.33.04.08

Grupo Intergubernamental de Expertos Sobre el Cambio Climático [IPCC]. (2014). *El quinto reporte de evaluación del IPCC. ¿Qué implica para Latinoamérica? Resumen ejecutivo*.

Grupo Intergubernamental de Expertos Sobre el Cambio Climático. Recuperado de https://cdkn.org/wp-content/uploads/2014/12/INFORME-del-IPCC-Que-implica-para-Latinoamerica-CDKN.pdf.

Grupo Intergubernamental de Expertos Sobre el Cambio Climático [IPCC]. (2015). *Cambio climático 2014. Informe de síntesis.* Ginebra, Suiza: Grupo Intergubernamental de Expertos Sobre el Cambio Climático. Recuperado de https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full_es.pdf.

Hernández, V. M., Jiménez, G. D., García, J. G., Jiménez, L. J., Orozco, B. H., Hernández, L. M. y Morales, A. T. (2015). Riesgo y vulnerabilidad del maíz de temporal en la región suroeste del estado de Tlaxcala frente al cambio climático. *Biológico Agropecuaria Tuxpan, 3*(5), 1009-1018. Recuperado de http://revistabioagro.mx/wp-content/uploads/2017/03/Riesgo-y-vulnerabilidad-del-ma%C3%ADz-de-temporal-en-la-regi%C3%B3n-suroeste-del-estado-de-Tlaxcala-frente-al-cambio-clim%C3%A1tico.pdf.

Hernández, V. M., García, J. G., Orozco, B. H. y Juárez, M.G. (2018). Vulnerabilidad socioambiental del maíz nativo frente al cambio climático en el estado de Tlaxcala, México. *Revista iberoamericana de las ciencias biológicas y agropecuarias, 7*(14), 53-76.

Hernández, X. E. (1988) La agricultura tradicional en México. *Comercio Exterior, 3*(8), 673-678. Recuperado de http://revistas.bancomext.gob.mx/rce/magazines/189/2/RCE2.pdf.

Madrigal, A. (2008). Los campesinos se declaran inocentes: Cambios estructurales y contaminación genética del maíz criollo en san Antonio Atotonilco, Municipio de Ixtacuixtla, Tlaxcala. En Ortiz, B. y Duval, G. (coords.), *Sistemas complejos medio ambiente y desarrollo* (pp. 97-132). México: Lupus Inquisitor.

María, A., Hernández, J. M., Muñoz de la Vega, E. y Ríos, S. A. (2015). *Informe final del proyecto el Proyecto FZ016. Conocimiento de la diversidad y distribución actual del maíz nativo y sus parientes silvestres en México segunda etapa 2008-2009.* Tlaxcala, México: Comisión Nacional para el Conocimiento y uso de la Biodiversidad. Recuperado de http://www.conabio.gob.mx/institucion/proyectos/resultados/InfFZ016_TLAXCALA.pdf.

Meza, E. L. (2014). La agricultura familiar y el cambio climático. En Organización de las Naciones Unidas para la Alimentación y la Agricultura [FAO], *Agricultura familiar en América Latina y el Caribe. Recomendaciones de política* (pp. 79-100). Santigo, Chile: Organización de las Naciones Unidas para la Alimentación y la Agricultura. Recuperado de http://www.fao.org/3/i3788S/i3788S.pdf.

Olmos, M. E., Gonzales, M. E. y Contreras, M. R. (2013). Percepción de la población frente al cambio climático en áreas naturales protegidas de Baja California Sur, México. *Polis*, *12*(35), 1-17. Recuperado de https://research.fit.edu/media/site-specific/researchfitedu/coast-climate-adaptation-library/latin-america-and-caribbean/guyana-suriname-fr-guiana/Olmos-Martinez-Et-Alia.-2013.-CC,-Percepcion-De-La-Poblacion.-Baja-California-Sur,-Mexico-[esp].pdf.

Oltra, C., Solá, R., Sala, R., Prades, A. y Gamero, N. (2009). Cambio climático: Percepciones y discursos públicos. *Prismasocial*, (2), 1-23. Recuperado de http://www.isdfundacion.org/publicaciones/revista/pdf/n2_9.pdf.

Organización de las Naciones Unidas para la Alimentación y la Agricultura [FAO]. (2016). *Cambio climático y seguridad alimentaria y nutricional América Latina y el Caribe*. *(Orientaciones de política)*. Santiago, Chile: Organización de las Naciones Unidas para la Alimentación y la Agricultura. Recuperado de http://www.fao.org/fileadmin/user_upload/rlc/docs/Cambioclimatico.pdf.

Organización de las Naciones Unidas para la Alimentación y la Agricultura [FAO]-Secretaría de Agricultura y Desarrollo Rural [SAGARPA]. (2012). *México: El sector agropecuario ante el desafío del cambio climático* (vol. I). México: FAO-SAGARPA Recuperado de http://www.sagarpa.mx/programas2/evaluacionesExternas/Lists/Otros%20Estudios/Attachments/37/Cambio%20Climatico.pdf.

Orozco, B. H., García, J. G., Hernández, V. M. y Juárez, M. G. (2016). Disminución en la frecuencia de uso en maíces de color en dos regiones de Tlaxcala. *Biológico Agropecuario Tuxpan*, *5*(7), 1348-1356. Recuperado de http://revistabioagro.mx/wp-content/uploads/2016/08/.

Pinilla, M. C., Sánchez, J., Rueda, A. y Pinzón, C. (2012). Variabilidad climática y cambio climático: percepciones y procesos de adaptación espontánea entre campesinos del centro de Santander Colombia. Resultados obtenidos durante el desarrollo de la línea base para el Convenio 46/3379, suscrito entre Isagen E. S. P. y Fundación Natura en el marco del Plan de Manejo Ambiental del Proyecto Hidroeléctrico Sogamoso.

Programa de Apoyos Directos al Campo [Procampo]. (2016). *Maíz de temporal*. *Bases de datos primavera verano 2016, estado de Tlaxcala*. Tlaxcala, México: Programa de Apoyos Directos al Campo.

Reyes, G. G., Guerra, N. J. y Calderón, P. G. (2005). Condiciones de cultivo del maíz criollo en comunidades de Puebla, Tlaxcala e Hidalgo: un análisis de las economías de autoconsumo. *Aportes,* *9*(29), 63-82. Recuperado de http://www.eco.buap.mx/aportes/revista/29%20Ano%20X%20Numero%2029,%20Mayo-Agosto%20de%202005/06%20Condiciones%20de%20cultivo%20de%20maiz%20criollo%20en%20comunidades%20de%20Puebla,%20Tlaxcala%20e%20Hidalgo;%20un%20analisis%20de%20las%20economias%20de%20autoconsumo-Gerando%20Reyes,%20Jimena%20Guerra%20y%20Gilberto%20Calderon.pdf.

Rubio, B. A. (2011). Crisis mundial y soberanía alimentaria en América Latina. *Revista de economía mundial*, (29), 61-87. Recuperado de https://www.redalyc.org/articulo.oa?id=86622169002.

Salcedo, S. (2005). El marco teórico de la seguridad alimentaria. En Salcedo, S. (ed.), *En Políticas de seguridad alimentaria en los países de la Comunidad Andina* (pp. 1-8). Santiago, Chile: FAO. Recuperado de http://www.bvsde.paho.org/texcom/nutricion/seguridadCA/03cap1.pdf.

Sistema de Información Agroalimentaria y pesquera [SIAP]. (2018). *Anuario estadístico de la producción agrícola.* México: Sistema de Información Agroalimentaria y pesquera. Recuperado de www.gob.mx/siap/acciones-yprograma/produccion-agricola-33119.

Soares, D. y Gutiérrez, I. (2011). Vulnerabilidad social, institucional y de percepciones sobre el cambio climático: un acercamiento al municipio de San Felipe, Costa de Yucatán. *Ciencia Ergo Sum, 18*(3), 249-263. Recuperado de https://dialnet.unirioja.es/servlet/articulo?codigo=5035053.

Solís, R. J., De Jesús, R. y Salvatierra, I. B. (2013). Percepción social del cambio climático en áreas destinadas voluntariamente a la conservación en comunidades indígenas de Oaxaca y Chiapas. *Temas antropológicos, 35*(1), 29-53. Recuperado de http://www.redalyc.org/pdf/4558/455845082002.pdf.

Vander, M. K. (2011). Percepciones de cambio climático y estrategias de adaptación en las comunidades agrícolas de Cotacachi. *Ecuador Debate,* 145-158. Recuperado de https://repositorio.flacsoandes.edu.ec/bitstream/10469/4263/1/RFLACSO-E82-10-VanderMolen.pdf.

Vásquez, M. O. (2016). *Percepción del cambio climático por los agricultores de maíz en la zona oriente del estado de Tlaxcala*. (tesis). Licenciatura de Biología. Universidad Autónoma de Tlaxcala, México.

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