Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Vulnerabilidad socioambiental del maíz nativo frente al cambio climático en el estado de Tlaxcala, México

Socio Environmental Vulnerability of the Native Maize against Climate Change in the State of Tlaxcala, Mexico

Vulnerabilidade socioambiental do milho nativo às mudanças climáticas no estado de Tlaxcala, México

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Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Resumen

El estado de Tlaxcala no solo se caracteriza por ser productor de maíz de temporal, sino también por tener una importante diversidad genética de maíz nativo. A sabiendas de lo anterior, el objetivo de esta investigación fue analizar la distribución potencial de las razas de maíz nativo en este estado con la finalidad de identificar condiciones futuras que permitan prever la permanencia de este cultivo o su desaparición bajo escenarios de cambio climático. Se estudiaron los registros de cuatro razas primarias de maíz (cacahuacintle, chalqueño, cónicos y elotes cónicos) con una base total de 725 datos georreferenciados y se modelaron sus distribuciones potenciales con el algoritmo de Maxent. Se utilizaron los escenarios climáticos A1, A2, B1 y B2, proyectados al 2020, 2050 y 2080. Y de esta forma se generó un porcentaje de áreas de pérdida y ganancia con respecto a su distribución potencial actual. Los resultados indican que el maíz chalqueño será la raza más afectada con la mayor pérdida de áreas potenciales; mientras que del cacahuacintle se estiman pérdidas menores. Los datos aquí obtenidos ofrecen la posibilidad de diseñar estrategias de conservación eficientes para enfrentar las condiciones climáticas extremas.

Palabras clave: cambio climático, distribución potencial, escenarios climáticos, maíz nativo.

Abstract

The state of Tlaxcala not only is characterized by being a producer of seasonal maize by tradition but also has an important genetic diversity of native maize. Knowing that, the objective of this research was to analyze the potential distribution of the different types of native maize in this Mexican state in order to identify future conditions that will indicate their permanence or disappearance under climate change scenarios. The records of four primary maizes types (*Cacahuacintle, Chalqueño, Cónico and Elotes Cónicos*) with a total base of 725 geo-referenced data were studied and their potential distributions were modeled with the Maxent. Climatic scenarios A1, A2, B1 and B2, projected to 2020, 2050 and 2080, were used thus generating a percentage of areas of loss and gain with respect to their current potential distribution. The results indicate that *Chalqueño* maize will be the most affected type with the greatest loss of potential areas, whereas in *Cacahuacintle*, lower losses are estimated. The study allows to design efficient conservation strategies to deal with the extreme climatic conditions.

Keywords: climate change, potential distribution, climatic scenarios, native maize.

Resumo

Tlaxcala estado não só é caracterizada pela produção de milho temporária, mas também tem uma diversidade genética significativa de milho nativo. Sabendo disso, o objetivo desta pesquisa foi analisar o potencial de raças de milho nativo neste estado, a fim de identificar as condições futuras para prever a permanência da cultura ou do desaparecimento sob distribuição de cenários de mudanças climáticas. fichas quatro raças de milho primárias (cacahuacintle, Chalqueño, milho afunilada e cónica) com uma base total de 725 dados georreferenciados foram estudados e suas distribuições potenciais foram modelados com algoritmo Maxent. cenários climáticos A1, A2, foram utilizados B1 e B2, projetada para 2020, 2050 e 2080. E assim a percentagem de áreas de perda e ganho é gerado em relação à sua atual distribuição de potencial. Os resultados indicam que Chalqueño milho ser corrida mais afetada com a maior perda de áreas potenciais; enquanto do cacahuacintle perdas menores são estimadas. Os dados aqui obtidos oferecem a possibilidade de desenhar estratégias eficientes de conservação para enfrentar as condições climáticas extremas.

Palavras-chave: mudanças climáticas, distribuição potencial, cenários climáticos, milho nativo.

Fecha recepción: Diciembre 2017 **Fecha aceptación:** Mayo 2018

Introduction

The cultivation of corn is a very old activity. According to Monterroso, Conde, Rosales, Gómez and Gay (2010), it goes back to 7000 years of history throughout Mexico and Central America. And in the case of Mexico, it is not only a center of origin and diversity of biological forms of corn, but also of its forms of uses (Ortega, 2003, Aragón et al., 2006, Sánchez, 2011).

It should be noted that in this country the most complete classification of corn races has been made by Sánchez and Goodman (1992), Sánchez et al. (2000) and Ruiz et al. (2008), who considered 59 races arranged in 4 groups and some subgroups according to the similarity of their morphological, isoenzymatic and climatic characteristics of the collection site.

Historically, these maize races have been the essential nutritional base for millions of Mexicans (Van Etten, 2006, Monterroso et al., 2010). It is estimated that the consumption per person is 300 grams per day on average, and that it contributes 56% of calories and 47% of protein (González, 1995, Massieu and Lechuga, 2002). This seed also contains between 4% and 7% of lipids, from 8% to 11% of protein and from 69% to 86% of carbohydrates (Méndez et al., 2005, Castañeda, 2011, Salinas, Saavedra, Soria and Espinosa, 2008), as well as vitamin A and E and essential amino acids such as phenylalanine, histidine, isoleucine, leucine, lysine, methionine, threonine, tryptophan and valine (Castañeda, 2011). According to the Food and Agriculture Organization of the United Nations [FAO, for its acronym in English] (2016), these properties represent food security with access to the population of low socioeconomic status.

From the point of view of health, the seeds of blue, red, black, purple and purple colors contain anthocyanins, important substances in the prevention of human diseases (Espinosa, Mendoza, Castillo, Ortiz and Delgado, 2010; Aguilera, Reza, Chew and Meza, 2011). These are antioxidant compounds that prevent the damage caused by free radicals, with various qualities such as anti-cancer, anti-inflammatory, prevention and control of diabetes and antitumor, strengthening the immune system. In addition, they favor visual acuity and cognitive behavior (Castañeda, 2011; Aguilera *et al*., 2011).

In the Mexican state of Tlaxcala, seven races of corn are reported. Among which there are four dominant: cacahuacintle, chalqueño, conical and conical elotes (National Commission for the Knowledge and Use of Biodiversity [CONABIOonabio], 2011a). In this state, native corn is highly valued by farmers from the food, economic and sociocultural point of view (Aragón et al., 2006, Damián et al., 2010). Its production is traditional and seasonal based on native seeds (Orozco, 2016).

However, as some experts point out (Conde, Ferrer and Orozco, 2006, Gay et al., 2007, Tubiello and Fischer, 2007, Trujillo and Marrero, 2008), because they are exposed to extreme events such as droughts, torrential rains. , frosts and hail, planting corn under temporary conditions increases the risk levels and the degree of vulnerability due to the high probability of disasters. Predictions about the impacts of climate change indicate that production in quantity and quality will be reduced and the welfare effects of thousands of farmers will be very severe (Altieri and Nicholls, 2009), which will force them to use new agricultural practices in response to the modifications of these conditions. Among these alternatives is to stop cultivating native maize and, instead, plant improved and genetically modified seeds, which would increase food dependence by up to 80% (Massieu and Lechuga, 2002).

It is important to note that climate change does not impact in the same way in all regions; in fact, some may be favored (Kundzewicz et al., 2007). This means that the different races of maize are adapted to particular climatic conditions, therefore, the impacts of climate change on maize breeds will be different (Aragón et al., 2006). This situation can be exploited to maintain a biological wealth of germplasm and to adapt in a natural way resistant varieties to certain extreme environmental conditions, being the best way to guarantee the conservation of the breeds in the field (Martínez and Ureta, 2009; Ureta, Martínez, Perales and Álvarez, 2011; Ureta, González, González, Álvarez and Martínez, 2013).

On the other hand, the development of scenarios and predictions by means of climate models has almost always been done in first world countries and rarely in developing countries. Even so, in Mexico, some work on prediction modeling in climate change has been elaborated (Conde and Gay, 2008). According to the Intergovernmental Panel on Climate Change (IPCC, for its acronym in English), the elaborations of climate change scenarios are essential for the implementation of adaptation and mitigation strategies in the face of climate change (Carter et al., 2007; Randall et al., 2007).

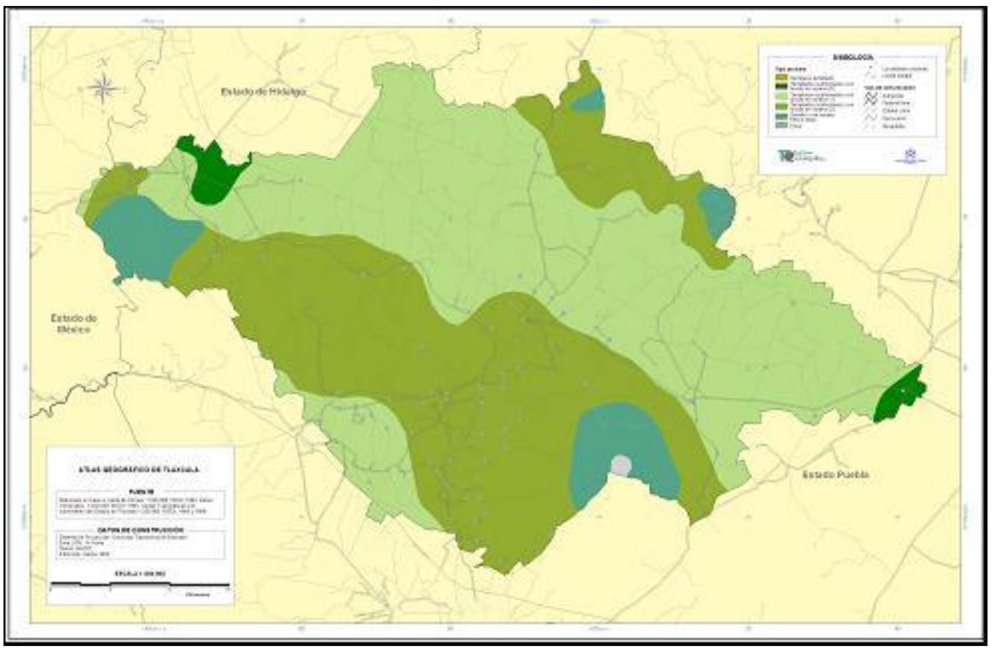
All of the above leads us to evaluate the potential distribution of maize races under different climate change scenarios in order to obtain information on the increase or decrease of the presence of each breed and thus identify which are most at risk of disappearing and which they will be more successful under future climatic conditions. It will also be possible to know the place where certain breeds can be sown, and in this way to design adaptive strategies that allow facing the changing extreme conditions of the climate without the need to compromise the security of biodiversity.

Method

Study area

The state of Tlaxcala is located geographically in the central-eastern region of Mexico between 97 ° 37 '07 "and 98 ° 42' 51" west longitude and 19 ° 05 '43 "and 19 ° 44' 07" of latitude north, located in the highlands of the neovolcanic axis, on the plateau of Anahuac. Its average altitude is 2230 m. n. m. (National Institute of Statistics and Geography [INEGInegi], 2010) (see figure 1).

Figura 1. Ubicación geográfica del estado de Tlaxcala



Fuente: INEGI~~negi~~ (2010)

The georeferenced records of maize, meanwhile, were obtained from the CONABIOonabio database (2011b). It found that there are seven races of native corn: yellow arrocillo (2), cacahuacintle (16), celaya (2), chalqueño (74), conical (555), conical corn (80), palomero toluqueño (4) and not associated with a racial complex [ND] (55) but who are natives of the state. This is: a total of 788 records.

Species distribution model

In order to identify the areas of potential distribution of native maize in Tlaxcala that will remain or will be lost in the future in the face of the effects of climate change, the environmental variables belonging to the families of greenhouse gas emissions A1, A2, were used. B1 and B2, corresponding to the General Circulation Model [MCG] (IPCC, 2000), projected to the climate simulations that will be in 2020, 2050 and 2080. These models have demographic, social, economic and technological change characteristics that coincide with the general context that prevails in the state of Tlaxcala, reason why they are considered of great importance.

Current and future distribution models were constructed from the Maxent algorithm, an artificial intelligence method that applies the principle of maximum entropy to calculate the most probable geographical distribution for a species (Elith et al., 2006; Phillips, Anderson and Schapire, 2006; Pearson, Raxworthy, Nakamura and Townsend, 2007). It should be added that the principle of maximum entropy is similar to other Bayesian methods in which the existing information is used.

Maxent in a deterministic algorithm that guarantees that it will converge in the Maxent probability distribution. At the end of the iteration process, Maxent assigns a negative probability to each pixel of the total area of study; at the end they must add one. Then a correction value is applied to make them positive and add up to 100%. Since each pixel has very small values, Maxent gives the result of the sum of the value of that pixel and of all the other pixels with an equal probability value. These values can range from 0 to 100 and indicate the probability of occurrence of the species. The program is loaded with variables or bioclimatic layers in ASCII code (downloaded from the WorldClim page), with presence data, with name of the species and decimal coordinates in .txt format (available in Excel). Values such as the convergence threshold = 10-5 and iterations of 500 can be maintained. Empirically, they have been observed to work well; they are conservative but allow the algorithm to arrive near convergence. The result is distribution probability maps in ASCII and a result sheet in .html with images of the same maps in .png and a series of statistical validation data.

The environmental data are made up of 19 bioclimatic variables (Hijmans, Cameron, Parra, Jones and Jarvis, 2005): average annual temperature, average daytime interval, isotherms, temperature seasonality, maximum temperature of the hottest month, minimum temperature of the month more cold, average temperature of the wettest season, average temperature of the driest season, average temperature of the warmest season, average temperature of the coldest season, annual precipitation, precipitation of the wettest month, precipitation of the driest month, precipitation by season of the year, precipitation of the wettest season, precipitation of the driest season, precipitation of the warmest season, precipitation of the coldest season, digital cartography of land uses and vegetation of series I, II and III. The selected threshold to generate the binary models (presence / absence), from the models generated in Maxent, in order to eliminate overprediction that could obscure the distribution patterns, was the 10th percentile of the presence of training, which implies 10 % of omission of the data with which the model was generated.

Results

For the purpose of this analysis, the yellow arrocilla, celaya and palomero toluqueño breeds were eliminated, as were the ND data because they did not have significant records to be modeled. Therefore, we only worked with 725 records: 2.2% are from the Cacahuacintle breed, 10.2% from the Chalqueño breed, 76.6% from the conical breed and 11% from the conical crocks (see Figure 2).

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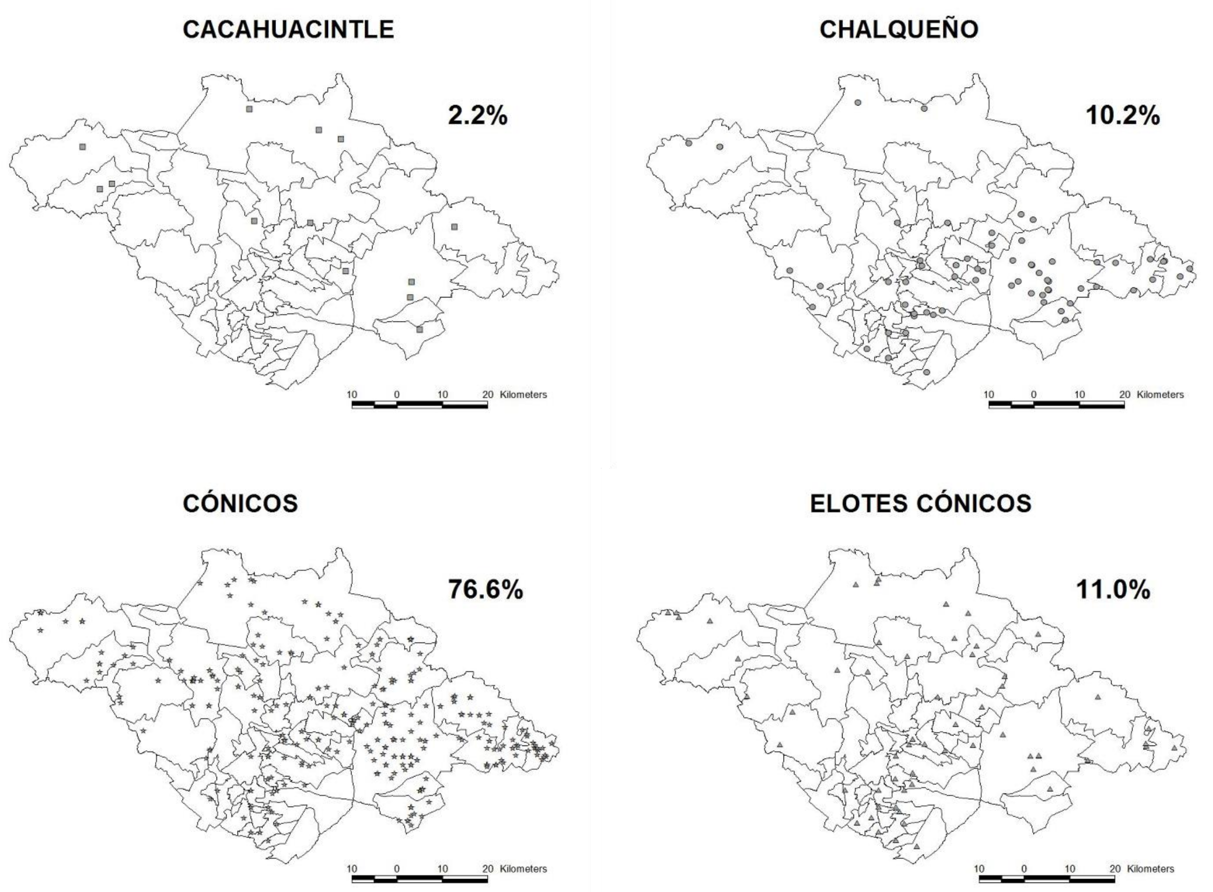
Figura 2. Distribución de maíz nativo en Tlaxcala



Fuente: Elaboración propia

According to the results of this quantification, two patterns of response of the races to climate change were determined: 1) gain: races with increases in their area of distribution with respect to the current time and 2) loss: races with decreases in their area of distribution with respect to the current time.

The potential distribution of each race was analyzed by combining the present with the years 2020, 2050 and 2080 in each of the scenarios (A1, A2, B1 and B2).

Among the most relevant results, it was found that the Chalqueño maize race will be the most affected, since an important part of areas with adequate environmental conditions for its permanence will be lost; or what is the same, the areas in which it can be sown will be reduced.

The A1-2050 scenario is the one that estimates the greatest loss (12.6%) of the area with respect to its current distribution. For this same race the general average indicates that in 2080 8.3% of these areas will be lost. It is a slightly later corn that is more exposed to extreme weather events.

The predominant maize in the state are those that belong to the conical races and conical elotes. In the case of that race, scenario B2-2050 predicts the greatest loss (8.0%) with respect to its current distribution; Concerning the conical ears, the worst scenario is the A2-2020, with a loss of 11% (see table 1).

Regarding the percentages per scenario, the results indicate that where there will be less losses of potential areas of these four races will be in the B1-2020 (5.0%), and behind this, with an increase in losses of 7.7%, the A1- 2050

Tabla 1. Porcentaje de área pérdida con respecto a su distribución potencial actual

Raza	Escenarios al 2020				Promedios
	A1	**A2**	**B1**	**B2**	
Cacahuacintle	5.2	3.5	3.3	5.3	4.3 %
Chalqueño	10.5	7.9	5.5	7.2	7.8 %
Cónicos	7.4	6.1	4.9	6.8	6.3 %
Elotes cónicos	4.7	11.0	6.5	7.5	7.4 %
Promedios	7.0 %	7.1 %	5.0 %	6.7 %	
	Escenarios al 2050				
	A1	**A2**	**B1**	**B2**	
Cacahuacintle	3.4	4.5	6.1	5.6	4.9 %
Chalqueño	12.6	8.3	4.3	7.6	8.2 %
Cónicos	7.3	6.8	7.4	8.0	7.4 %
Elotes cónicos	7.3	2.9	7.8	5.6	5.9 %
Promedios	7.7 %	5.6 %	6.4 %	6.7 %	
	Escenarios al 2080				
	A1	**A2**	**B1**	**B2**	
Cacahuacintle	3.9	5.6	3.7	3.7	4.2 %
Chalqueño	10.1	10.4	6.1	6.6	8.3 %
Cónicos	7.1	6.7	4.6	6.8	6.3 %
Elotes cónicos	6.7	4.3	7.3	6.7	6.3 %
Promedios	7.0 %	6.8 %	5.4 %	6.0 %	

Fuente: Elaboración propia

The potential area gained will mean the possibility of sowing certain breeds. In this regard, it was found that the Cacahuacintle race will suffer the least losses of potential areas: the B1-2020 scenario predicts a 20% gain of the area with respect to its current distribution, and also the overall average of 2020 is the one that shows the highest gain with 16.7%. After this race the conical ones follow with 5.4% -7.0% and the conical ears with 5.9% -7.6% (see table 2).

On average, in scenario B1-2020 you gain up to 8.0% of potential areas. And this same scenario, but in the 2050 projection, it represents only a gain of 5.4%.

Tabla 2. Porcentaje de área ganada con respecto a su distribución potencial actual

Raza	**Escenarios al 2020**				**Promedios**
	A1	**A2**	**B1**	**B2**	
Cacahuacintle	14.4	18.5	20.0	13.7	16.7 %
Chalqueño	0.0	0.2	0.6	0.4	0.3 %
Cónicos	5.1	5.8	6.6	5.4	5.7 %
Elotes cónicos	5.9	2.5	4.7	4.2	4.3 %
Promedios	6.4 %	6.8 %	8.0 %	5.9 %	
	Escenarios al 2050				
	A1	**A2**	**B1**	**B2**	
Cacahuacintle	19.1	15.6	11.4	12.6	14.7 %
Chalqueño	0.0	0.2	0.9	0.3	0.4 %
Cónicos	5.3	5.4	5.1	4.6	5.1 %
Elotes cónicos	5.3	7.6	4.0	5.2	5.5 %
Promedios	7.4 %	7.2 %	5.4 %	5.7 %	
	Escenarios al 2080				
	A1	**A2**	**B1**	**B2**	
Cacahuacintle	16.7	12.9	17.1	17.1	16.0 %
Chalqueño	0.1	0.0	0.5	0.4	0.3 %
Cónicos	5.3	5.4	7.0	5.4	5.8 %
Elotes cónicos	4.7	6.2	4.4	4.7	5.0 %
Promedios	6.7 %	6.1 %	7.3 %	6.9 %	

Fuente: Elaboración propia

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Discussion

Recent studies agree that the effects of climate change have consequences on the potential distribution of species at different scales and in different forms, for example, displacements, changes in distribution areas, composition of communities and functioning of ecosystems (Thuiller and Erhard, 2005; Thuiller et al., 2006, Broennimann et al., 2006; Pearson et al., 2007).

The models used are subject to different levels of uncertainty that include the amount of presence data of each of the races analyzed, the climate scenarios and the method of modeling ecological niches. However, the details of the models can not be an impediment to start generating information to guide decision making and should be considered that this type of methodology is a good tool to project future areas where you can have better performance and physiological performance of corn races (Martínez and Ureta, 2009).

The study of spatial modeling in the context of climate change makes it possible to evaluate the trends of change for the different races and, with that, to identify those that are potentially more vulnerable. Mexico has a great topographic, climatic and, consequently, ecological diversity that varies spatially in a very important way, a characteristic that is precisely responsible for the great biological diversity (Kato, Mapes, Mera, Serratos and Bye, 2009; Sánchez, 2011; Ureta et al. al., 2011). Modeling the potential distribution through the Maxent algorithm turns out to be an effective tool for the determination of potential areas of native maize in the state of Tlaxcala.

Under this perspective, although in another Mexican state, Tinoco, Gómez and Monterroso (2011) conducted a study that determines the potential distribution of corn in Jalisco, with climate change models GFDL-TR-90 and Hadley-TR- 00 for the 2050 time horizon, and under the socio-economic scenario A2, which establishes a strong population growth and slow economic development. This study, although it does not specify the maize race with which it works, indicates an increase in the unsuitable surface for the cultivation of maize in 63.6% for the GFDL model and in 90.8% for the Hadley model, which implies that The impacts of climate change on rainfed maize can be disastrous.

In contrast, Ruiz et al. (2011), using the HadGEM2-AO and MIROC5 general circulation models for the period 2041-2060, under the greenhouse gas concentration pathways rcp4.5 and rcp6.0, found that the area with high environmental aptitude for conical corn In this respect, the route rcp4.5 is more favorable than the rcp6.0 of emissions and GHG concentration, since it considers a high aptitude increase that goes from 6% to 15%, including as one of the races that will mainly benefit of climate change in 2041-2060. However, for the state of Tlaxcala the conical race will on average lose between 6.3% and 7.4% of potential area, and it is scenario B2 that estimates the highest loss (8%). This breed is cultivated in high and temperate zones and it is tolerant to the cold, reason why it is gotten to cultivate in the skirts of the Malinche and in all the state.

The conical ears, on the other hand, are sown in high and cold parts and have high production of pigments. These maizes are an attractive raw material to produce food products high in antioxidants (Salinas, Pérez, Vázquez, Aragón and Velázquez, 2012). The map made with the information obtained from the Global Project of Native Maize indicates that the state of Tlaxcala has the potential to cultivate this breed (CONABIOonabio, 2011a). However, this study estimates an average loss between 5.9% and 7.4% potential area; it is in scenario A2 that there are more losses (11%).

However, over the rest, it is the Chaldean race that is most threatened by the effects of climate change in the coming decades (Ruiz et al., 2011). This corn is of great socioeconomic importance in the state, but it requires good soil and moisture conditions (Ortega, 2003; CONABIOonabio, 2011a). And despite the uncertainty of the modeling, it is possible that there is a real risk for this breed. Chalqueño is sown by cultural influence and is part of daily food in different ways, according to Hallauer (2001).

In relation to this crop, in the experimental fields of Santa Lucia Coatlinchán and the Montecillos Postgraduate College of the State of Mexico, 24 blue corn varieties of the Chalqueño race and the H-139 variety as a control (hybrid) were evaluated. observed that the grain yield of the blue corn varieties varied from 2.9 to 5.4 ton / ha, below the control H-139, which yielded 6.5 ton / ha; from which it is possible to assign greater adaptability and yield to hybrid corn under rainfed conditions (Antonio et al., 2004). These results show the vulnerability of the maize of the Chalqueño race and coincide with those of this research, which leads to look for alternatives that diminish the impacts in the cultivation of this race.

Regarding the Cacahuacintle race, projections of future scenarios were estimated with the most important area gains. This corn is cultivated mainly in soils of volcanic origin and occasionally in the high valleys of the center of the country, in high parts and with low temperatures; Another important characteristic is that it is resistant to hail (Ortega, 2003;

CONABIOonabio, 2011a). Although, thanks to the empirical knowledge and experience of the farmers of cacahuacintle corn, it has been possible to achieve an increase in the yield or productivity of the plant, its characteristics and the adaptability of the seed in different types of soil. This progress has also been possible due to the exchange of seeds between different localities over time. This has led to greater genetic uniformity in ear morphology (Herrera et al., 2004). However, although environmental factors favor this breed, the socioeconomic factors affect the farmer, since in the state is sown very little due to the instability in its price, which was in the year 2009 from 3000 to 10 000 pesos per ton (Sarmiento and Castañeda, 2011); therefore, the little interest to cultivate it, besides that they can only sell their harvest to the so-called intermediaries.

Now, returning to purely environmental factors, Ruiz et al. (2011) conclude that there will be a reduction of surface area with optimal agroclimatic conditions for corn production in the tropics, subtropics and transitional zones; instead, optimal surfaces will be increased in high valleys and very high valleys. This information coincides with the results of this research, in at least three of the four races studied.

Climate is a determining variable in the production of corn, as Martinez (2004) has pointed out, particularly because in Mexico it is one of the crops most vulnerable to climate change within the agricultural sector. Conde et al. (1997) and Gay et al. (2007) report that approximately 75% of farmers plant native maize in rainfed season, exposed to drastic weather conditions to obtain a high yield. However, Martínez (2009) mentions that these conditions of climate change are imminent and for a long time scenarios for the cultivation of corn, so the investigation should be directed to the search of different native breeds and their Mexican wild relatives of corn, with potential of adaptation to particular climatic conditions, as well as to the research and implementation of protection measures towards this grain due to its sociocultural, biological and economic importance. In addition, it is important to create regional strategies that allow the conservation of native breeds through germplasm and minimize the vulnerability of maize to different climate change scenarios.

Conclusions

The scenario that records the most losses of areas with adequate environmental conditions for native corn is the A1. In this scenario we expect very fast economic growth in the future, a rapid development of new technologies and an increase in the average annual temperature of 1.4 ° C-6.4 ° C. On the other hand, the scenario with the most gains from potential areas is scenario B1. This includes the development of clean technologies and global solutions towards sustainability and an increase in annual temperature between 1.1 C and 2.9 C. Without a doubt, the characteristics of the scenarios influence the loss or gain of potential areas.

As we have seen, Tlaxcala is considered the center of origin and domestication of native corn. So modeling it with climate change scenarios is crucial for society in general. In this way you will have information about the years 2020, 2050 and 2080 of the gain or loss of potential areas. This research is relevant for the institutions and non-governmental organizations that protect the native seed; It can be a pillar for decision making in the design of strategies that seek conservation in the region. This does not put at risk the food security of millions of people in the future.

Therefore, if you intend to protect native corn, the results of this study will: a) raise awareness of the potential distribution of native corn to producers, institutions and academics to make strategic decisions that mitigate the effects of change climate change and the vulnerability of seeds, tending to a public policy that guarantees food security; b) rescue the indigenous knowledge of native corn producers to promote organic agriculture for the benefit of the population and the environment, and c) it is important to continue doing comparative research with the first scenarios (A1, A2, B1, B2) and more recent (RPCs) that allow to contrast their variables, and thus have a more comprehensive analysis on the behavior of agricultural food production.

The Vicente Guerrero Group, located in the municipality of Españita of the state, considers that the production of corn is disadvantaged especially for the peasants and peasants. Because, under the pretext of increasing productivity, transnational companies would introduce patented seeds that would seriously harm native corn. At that time a policy is developed in defense of native corn. In addition, the LXI Legislature of the Congress of Tlaxcala unanimously approved the Law of Promotion and Protection of Maize as Original Heritage, in Constant Diversification and Alimentary, from which the Tlaxcalan Creole corn was declared as "Food Heritage of the State of Tlaxcala" , and one of its main objectives was to promote the sustainable development of native maize, based on the establishment of protection mechanisms that promote the continuity of its biological diversification process.

Acknowledgment

The authors thank the Project Supported by the Sectoral Fund for Environmental Research, with code 263096, SEMARNAT-CONACYT 2015.

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Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
ISSN: 2007 - 9990

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