Atmospheric and Climate Sciences, 2014, 4, 931-940
Published Online December 2014 in SciRes. http://www.scirp.org/journal/acs
http://dx.doi.org/10.4236/acs.2014.45082

Scientific Research

Climate Change and Its Influence on Agricultural Pest in Mexico

Carlos Contreras Servín, Guadalupe Galindo Mendoza

Coordination for Innovation and Application of Science and Technology, Autonomous University of San Luis Potosi, San Luis Potosí, Mexico
Email: Coser@uaslp.mx

Received 26 October 2014; revised 29 November 2014; accepted 16 December 2014

Academic Editor: Mohammad Valipour, University of Tehran, Iran

Copyright © 2014 by authors and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY).
http://creativecommons.org/licenses/by/4.0/
Open Access

Abstract

The present paper reviewed the researches of how they have affected agricultural pests in the territory of Mexico. It emphasizes that traditional climate models are not "predict" non-linear systems and are necessary to resort to the construction of scenarios for study. Some climate change models applied to Mexico used for this purpose obtained significant results. It showed that to better understand the ecology of pests and their hosts, it is necessary to further research the correlations between them and improve climate modeling and its consequences, to prioritize risks and improve the reliability of predictions and scenarios in the future.

Keywords

El Niño (ENSO) and Its Relationship with the Agricultural Pests, Climate Variability and Its Effect on Agricultural Pests, Pests, Plant Health, Climate Change

1. Introduction

From a climatic point of view-agricultural, variations on the precipitation that falls over the year or several years can cause droughts, the importance of this phenomenon is not only evident in the cultivation of the plants and agricultural production, but that can contribute to the emergence of plant disaster, due to their effects on the development and behavior of the causative organisms of pests. However, of all the environmental factors, which exerts a greater effect on the development of insects is probably the temperature. This is mainly due to its significant impact on the biochemical processes, to be agencies poikilotherms, *i.e.* take the temperature of the environment [1]. The increase in temperature also favors the increase in population densities of insects and mites.

How to cite this paper: Contreras Servín, C. and Galindo Mendoza, G. (2014) Climate Change and Its Influence on Agricultural Pest in Mexico. *Atmospheric and Climate Sciences*, **4**, 931-940. http://dx.doi.org/10.4236/acs.2014.45082

The higher the temperature the life cycle of the arthropods is shortened, so that you can present the higher number of generations in a single cycle of agricultural production. In physiological terms, an insect must accumulate a certain amount of heat in order to develop; this accumulated heat is measured in units that are called "degree-days" [2]. The increase of the temperature at which develops a kind of insect it accelerates the rate of development, and therefore, increases the number of generations that has during the year [3]. Since then, this behavior may be different in many species, but occurs as well in a general way [4]. In any way, when a region is heated to extreme levels and for prolonged periods, this favors the existence and the development of certain species, some that significantly increase their populations and other who manage expand their range of natural presence, colonizing new areas. In this regard it is important to mention that the International Plant Protection Convention (IPPC) defines the term pest as "any species, breed or biotype of plant, or animal or pathogenic agent injurious to plants or plant products" [5]. Also, it is important to mention that epidemiology is a cause-effect relationship between exposure and disease, the epidemiological triangle is formed by the pathogen, host and environment (biotic and abiotic). Within this context, the effects of climate change are a reality in the agriculture and its impact on plant health were already visible and is likely to intensify in the future [6]. However, the study of the consequences of climate change for the risks related to the plant health is relatively new; this is in accordance with the evidence presented in several recent studies of the Organization of the United Nations Food and Agriculture [7]. A global scale, the seasonal pattern of temperatures and precipitation are the principal factors to determine the distribution of organisms in space [8]. However, this, insects and plants adapt to combinations of these factors through natural selection, although insects with periodic outbreaks occur especially in areas that are physically severe changes over time, which is considered one of the causes of global warming [9]. It being shown that outbreaks of insects, both in areas of temperate and tropical climates, have been followed by periods of drought, strong sunspot activity or combinations of drought and excessive humidity [10]. The increase in temperature also favors the increase in population densities of insects and mites. The higher the temperature the life cycle of the arthropods is shortened, so that you can present the higher number of generations in a single cycle of agricultural production [11].

2. Materials and Method

From the methodological point of view, the first step is to use climate models to compare climatic data on the known distribution of a pest with the relative distribution in the area. Such climatic conditions may be represented graphically by graphics. Noting the monthly average temperatures and temperature range, one can deduce the seasonal characteristics of the area; analyzing rainfall, the annual amount and distribution in the year, you can deduce what kind of weather graphics belongs and what their characters are. On the other hand, the general circulation models can be useful for determining the presence, establishment and spread of pests, in order to simulate future scenarios of the epidemics, although the majority of general circulation models operate in large scales of resolution [12]. However, it has begun to relate the periodic changes of the climate and extraordinary, to demonstrate how the global model for the prediction of El Niño phenomenon coincides with a greater number of pests, we can cite as example the public page of the "National System of Epidemiological Surveillance Phitosanitary (SINAVEF)" of Mexico, where the weather bulletins and alerts show how the changes of the "time", is related to a greater or lesser presence of certain pests [13].

As a second step, climates of Mexico charter, using a scale of 1:4,000,000 (**Figure 1**) and a Geographic Information Systems (GIS), where an overlap was performed in the ArcGIS program 9.3, at this point, it is important to mention that GIS represent an ideal for the treatment of plant information platform, allowing to store, capture, analyze and act within a single interface and integrated manner, the information of spatially georeferenced pest sampling data from the "Directorate of Plant Health of Mexico (DGSV)".

3. Study Area

Mexico is located between latitudes 32˚ and 14˚ North and 86˚ and 118˚ West. Mexico is considered within North America, along with Canada and the United States. The country covers a total area of 1,964,375 square kilometers. The territorial boundaries of the country are: To the north with the United States has a border of 3152 km long, shares borders with Guatemala and Belize 986 km of 196 km long [14]. Periodically, its territory was affected by meteorological phenomena such as hurricanes, droughts, floods, etc. These phenomena are sometimes associated with the phenomena of "El Niño (ENSO)". Then the periods in the years 2003 to 2011 in the "National Water Commission

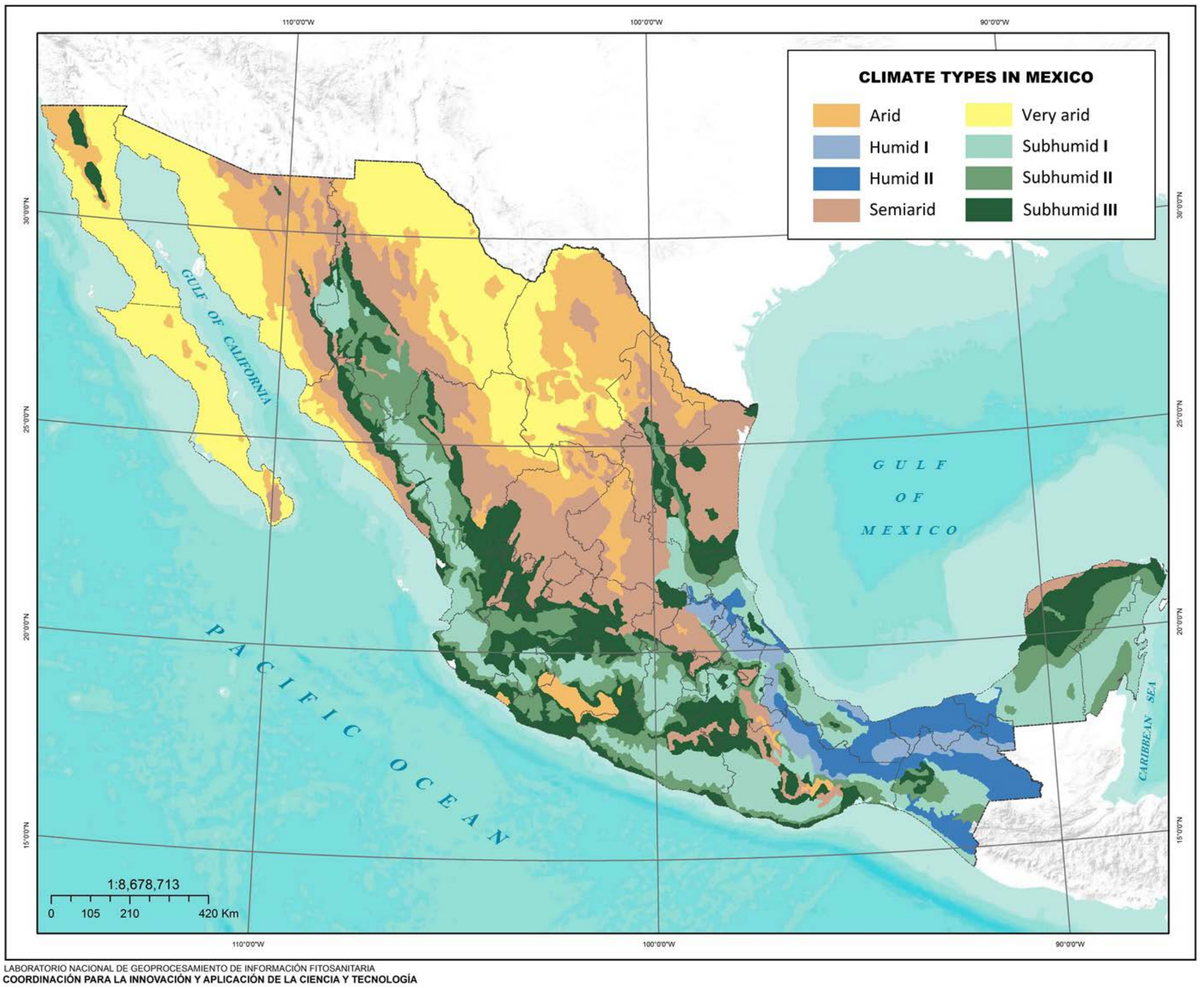


Figure 1. Climates of Mexico Charter. Institute of Geography, UNAM, 2000.

of Mexico (CNA)" http://smn.cna.gob.mx/ and this in turn with greater or lesser presence of some pests such as *Diaphorina citri* and Central American locust (*Schistocerca piceifrons piceifrons Walker*) DGSV, in order to observe and determine the areas and ways in which climate variability and change can affect reproduction, density, growth and survival of these pests and others. Below is a climate change model was used for possible scenarios in this regard is worth mentioning that the main climate change models that have been created are called "General Circulation Models and General Circulation Models of the Oceans". The advantage of these models is non-linear, that is, they have a linear behavior over time and the latest three-dimensionally performed [15].

Subsequently, the phenomenon of "El Niño" with changes in climate, due to the importance of the oceans for its high thermal capacity, related his great influence on the hydrological cycle and the absorption and exchange of carbon dioxide that is produced in them. It is noteworthy that due to the complexity and number of climate variables, climate change models are not predictions, but rather to climate projections. Another feature of the models developed so far is that yield good results that match how the projection of global temperature changes, but differ in the definition of weather patterns. The regional climate behavior is particularly complicated and there are just a few computational tools for study. We can summarize that climate models are not "predict" non-linear systems and are necessary to resort to the construction of scenarios for study. Some climate change models applied to Mexico show significant results, such as the 2000 study, according to the model CCC (Canadian Climate Center), focused on meteorological drought poses climate scenarios of how the country can be affected [16] these climate conditions, were correlated with the degree of future presence of agricultural pests, to determine which may be the context thereof (**Figure 2**).

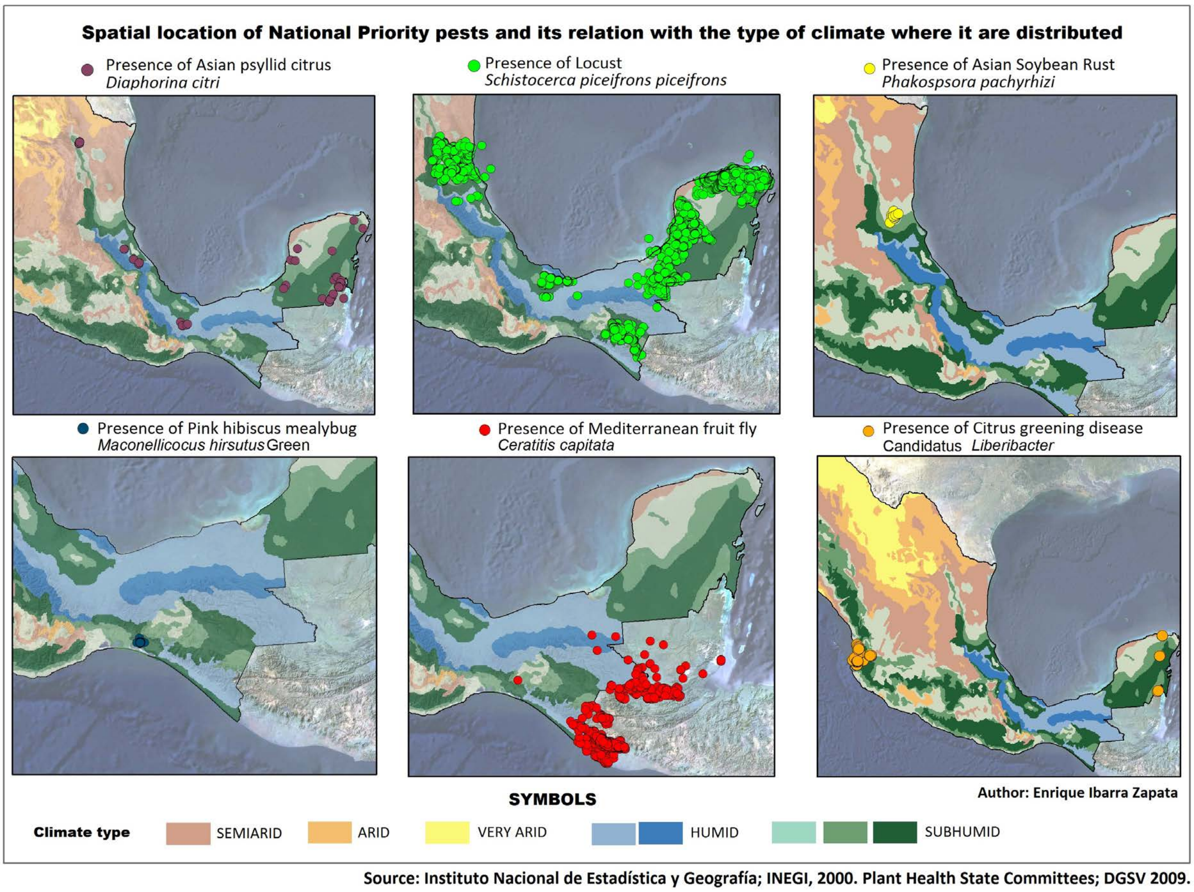


Figure 2. Relationship between climate-pest, with sampling data DGSV-Mexico. Year 2011.

4. Data Analyses

It is important to mention that the precipitation of the previous three groups of climates, are of the order of 500 to 2000 mm per year, with average temperatures above 20˚C and a period of drought from five to nine months. Notwithstanding this, we can say that the climate zones "warm humid (AW)", are the areas that most closely related to the agricultural pests. In this regard, it may be mentioned that in the Mexican Republic the places with climate Aw (map of climates according Köppen), stretch along the Pacific slope from the parallel 24˚N to the south until the state of Chiapas, in some of the lowest parts of the coastal plain of the Gulf of Mexico and also in most of the Yucatan peninsula, as well as in some inland areas, such as the Balsas Basin and the Central Depression of Chiapas. It appears, therefore, that this type of climate covers large areas of Mexico and the Köppen system gives only a general idea of variable conditions. Indeed, there are areas within Aw marked climatic differences, even over relatively short distances. These differences can be clearly seen if the rainfall data of stations, while having the same kind of weather compared Aw, are located towards the edge driest to the wettest and the corresponding zone. For example, Mérida, Yucatán, a town with Aw climate which is next to a dry climate BS area has much lower annual rainfall, about 960 mm, the San Pedro station, Tabasco, which is close to the folds of northern Chiapas and, therefore, the climate zone Am, and annual rainfall is 1550 mm. Another example is Solitude, Veracruz, Veracruz located in plains, away from the base of the mountains, which has less rainfall, about 952 mm annual Tierra Blanca, Veracruz, a town in the same region, but closer the Sierra Madre Oriental and has 1421 mm of annual rainfall. These differences are too small, it is hardly identifiable, so that such a general system like Köppen's record, they are nevertheless very important from the point of view of their influence on the environment, so that impact decisively on the vegetation, agriculture and pests.

Consequently, it obviates the need to highlight these differences by subdividing the type of climate in Köppen Aw several subtypes. In order to compare data from different weather stations with Aw climate and achieve desirable subdivisions, was taken as a basis of comparison the quotient obtained by dividing the total annual rainfall in millimeters between the average annual temperature in ˚C or Ratio P/T of each. This value represents the relationship between the two most important elements of the weather and the moisture content is known as index Lang. The P/T ratios of 340 stations in Mexico with BS type of climate (arid), which is the lower hierarchy Aw climate, in a series of immediate moisture values were pooled. The theoretical maximum (Mx) of this series, for which a value of Mx = 43.2 was obtained was calculated. The P/T ratios seasons with drier climate between climate Aw is less than the value obtained for the theoretical maximum number of ratios P/T stations BS climates, *i.e.*, are less than 43.2, so theoretically are encompassed within the type of climate BS. The set of weather stations Aw, the ratio P/T is less than 43.2, you are considered as constituting a new climate subtype designated with the symbol Aw_0. The station whose ratio P/T is greater than 55.3 is therefore wetter of Aw and are designated with the symbol Aw_2. The locations whose ratio P/T is between 43.2 and 55.3, that is, which are intermediate, in the Aw climates in their moisture content, they were classified as Aw_1. Thus Aw climate type was divided into three subtypes based on the moisture content: Aw_0, less humid; Aw_1, intermediate; and Aw_2, the wettest [17]. In particular the vector *Diaphorina citri* and disease spread through the bacterium *Candidatus Liberibacter asiaticus* (HLB), affects the production of citrus which Mexico is a major exporter, is related to the Aw climates [18], as shown in **Figure 3** and **Graph 1**, over 80% of the positive to the disease caused by HLB cases corresponds Aw climate, but in a more detailed assessment can be said that about 60% of positive cases are found in subtype Aw_0 for this reason is of particular interest to study this subtype of weather.

5. Results and Discussion

To relate this with the variability and climate change, it can be said that the phenomenon of "El Niño" climate impacts in Mexico causing more precipitation in winter and low rainfall in summer. Winters and Child, meanwhile, are colder in most of the country, while summers are drier and child. Thus, the presence of El Niño in the Mexican territory is intimately linked with the availability of water. The lack of rainfall in some years is perhaps the most obvious sign of a strong El Niño, and costs are the drought most resent in Mexico, affecting agricultural production [19]. Moreover, based on the information in the "National Water Commission of Mexico", the state of Yucatan, Gulf of Mexico and central-west of the country, experienced a major drought anomalous during the years of 2009-2011 (**Figure 4**), which represent for *Diaphorina citri*, a period of survival above normal and ideal

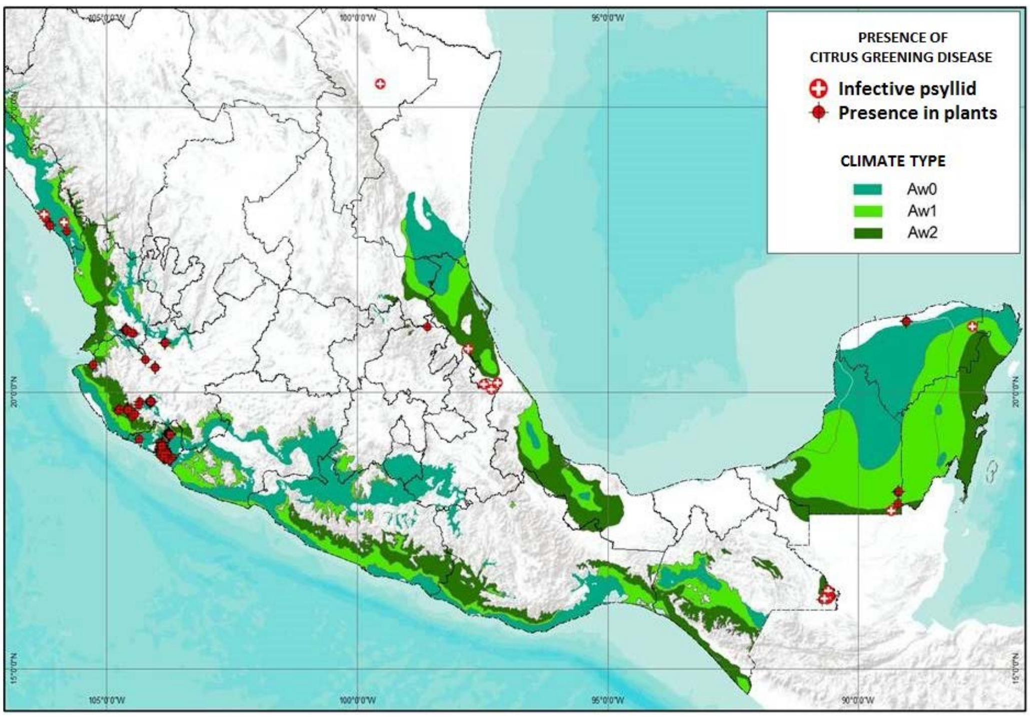
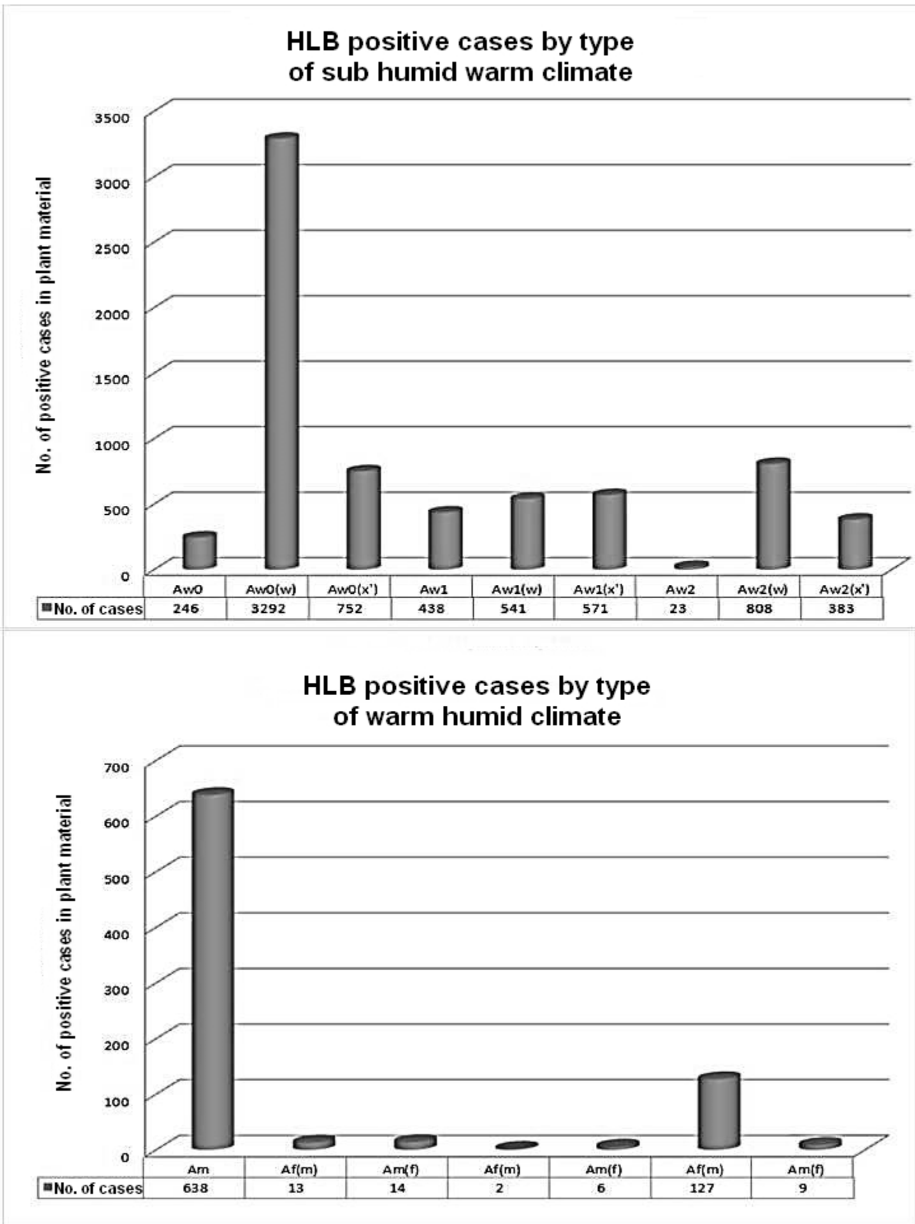


Figure 3. Relationship of HLB diseases in warm humid climate (Aw). Year 2011.



Graph 1. Number of positive cases of disease caused by HLB in humid and sub-humid climates with sampling data DGSV. Year 2011; Source: DGSV-Mexico.

conditions for tested positive to the disease *Candidatus Liberibacter asiaticus* (HLB), as evidenced by the fact that the year 2009, presented climate anomalies associated with the phenomenon of "El Niño", like the year 2002 that was recorded for the first time in *Campeche Diaphorina citri*, both years were characterized by the presence of the phenomenon of "El Niño", so let's say that the biological development and normal range of survival is favored, made to match cases: plague of Central American locust (*Schistocerca piceifrons piceifrons Walker*), Mediterranean fruit fly (*Ceratitis capitata*) and pink mealybug (*Maconellicoccus hirsutus*) and other pests [20] (**Figure 2**).

Based on the foregoing, it can be said that by linking the regions where field sampling of "General Directorate of Plant Health of Mexico (DGSV)" has tested positive for the disease HLB (*Candidatus Liberibacter asiaticus*) in years 2009 to 2011 (**Figure 4**), it has been observed that the warm humid climate (Aw_0), the climate is more related to the field records of the disease. Another example of how the phenomenon of "El Niño" can modify the climate of a region, meteorological records and field sampling DGSV, in the state of Tabasco, a place where the

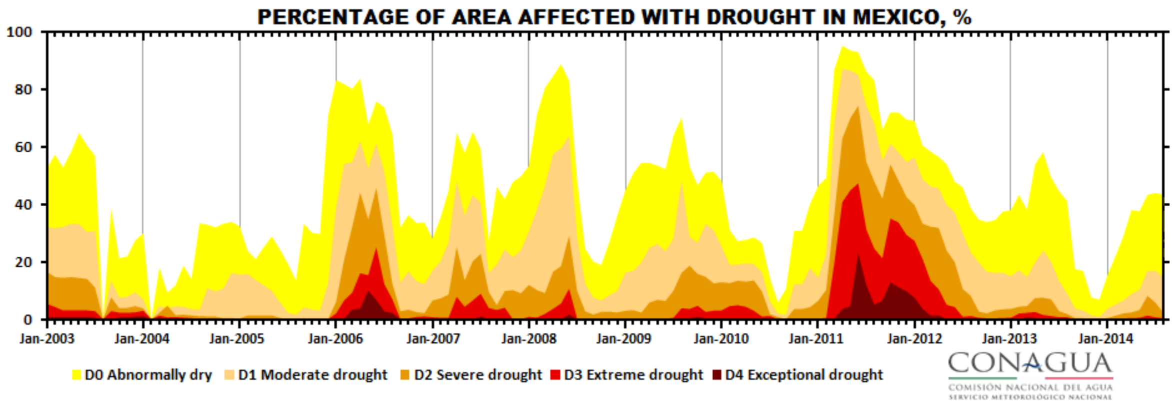


Figure 4. Mexico area affected by drought. Years 2003-2011.

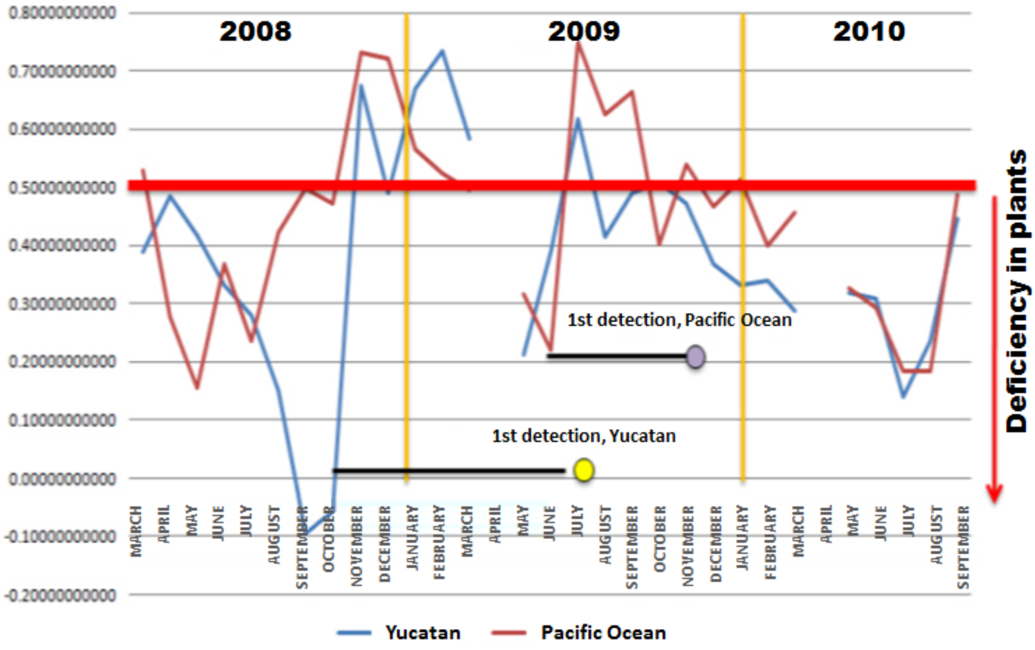
average rainfall is observed more 2000 mm per year and usually give rise to type climates "Warm wet", this weather is not conducive for breeding locusts, however, in exceptional years like 2009 or 2011, the climate can be behave in much of the year, as climates "dried or semiarid (BS)" or "sub-humid (Aw_0)" climates that are ideal for the reproduction of the locust [21].

After observing the results obtained, we can say that most of the plagues of national priority are located in the ecological zones of the warm-humid forests and to a lesser extent in the warm-dry, particularly in the areas of climate Aw_0, related to the above, for example the vector *Diaphorina citri* and bacteria *Candidatus Liberaribacter* (HLB) which carries this *psyllid* has been particularly set forth in the aforementioned sub-humid hot climates (Aw_0). However, it has been observed further expansion of *D. citri* and HLB at times when the weather Aw_0 recorded lower annual rainfall or periods of drought and abnormal time behaves as a semi-arid climate or BS. Moreover, the warm subhumid with summer rains (Aw_0), considered the driest tropical climate with an average annual rainfall of 900 mm, is the ideal climate that allows the environmental conditions for the biological development of locust (*Schistocerca piceifrons piceifrons Walker*), particularly on the coast of the Gulf of Mexico, coincide with the areas of exploration and sampling of the locust control campaign (**Graph 2**). This is important, because it is a climate found at the edge of tropical climates and dry climates, which is why the annual isohyet 900 mm becomes relevant because future, may be an important parameter for regionalize the sampling areas. This considerably expands pest invasion area in years "Niño" weather that anomalous droughts affect the breeding locust, as was documented in the period 2009-2010 (**Figure 4**).

6. Summary and Conclusion

After observing the results obtained, we can say that most of the plagues of national priority are located in the ecological zones of the warm-humid forests and to a lesser extent in the warm-dry, particularly in the areas of climate Aw_0, related to the above, for example the vector *Diaphorina citri* and bacteria *Candidatus Liberaribacter* (HLB) which carries this psyllid has been particularly set forth in the aforementioned sub-humid hot climates (Aw_0). However, it has been observed further expansion of *D. citri* and HLB at times when the weather Aw_0 recorded lower annual rainfall or periods of drought and abnormal time behaves as a semi-arid climate or BS. Moreover, the "warm subhumid with summer rains (Aw_0), considered the driest tropical climate with an average annual rainfall of 900 mm, is the ideal climate that allows the environmental conditions for the biological development of locust (*Schistocerca piceifrons piceifrons Walker*), particularly on the coast of the Gulf of Mexico, coincide with the areas of exploration and sampling of the locust control campaign. This is important, because it is a climate found at the edge of tropical climates and dry climates, which is why the annual isohyet 900 mm becomes relevant because future, may be an important parameter for regionalize the sampling areas. This considerably expands pest invasion area in years "Niño" weather that anomalous droughts affect the breeding locust, as was documented in the period 2009-2010 (**Figure 5**).

A previous cases of agricultural pests, you can add the appearance other calamities as the pink mealybug (*Maconellicoccus hirsutus*) among others. All these events, let say that the presence, establishment and spread of pests that affect agriculture, can be provided using the forecast phenomenon "El Niño" and how this changed climate conditions in some regions Mexico, in particular the regions located on the coast of the Gulf of Mexico



Graph 2. Relationship of drought in the arrest of HLB disease. Source: DGSV.

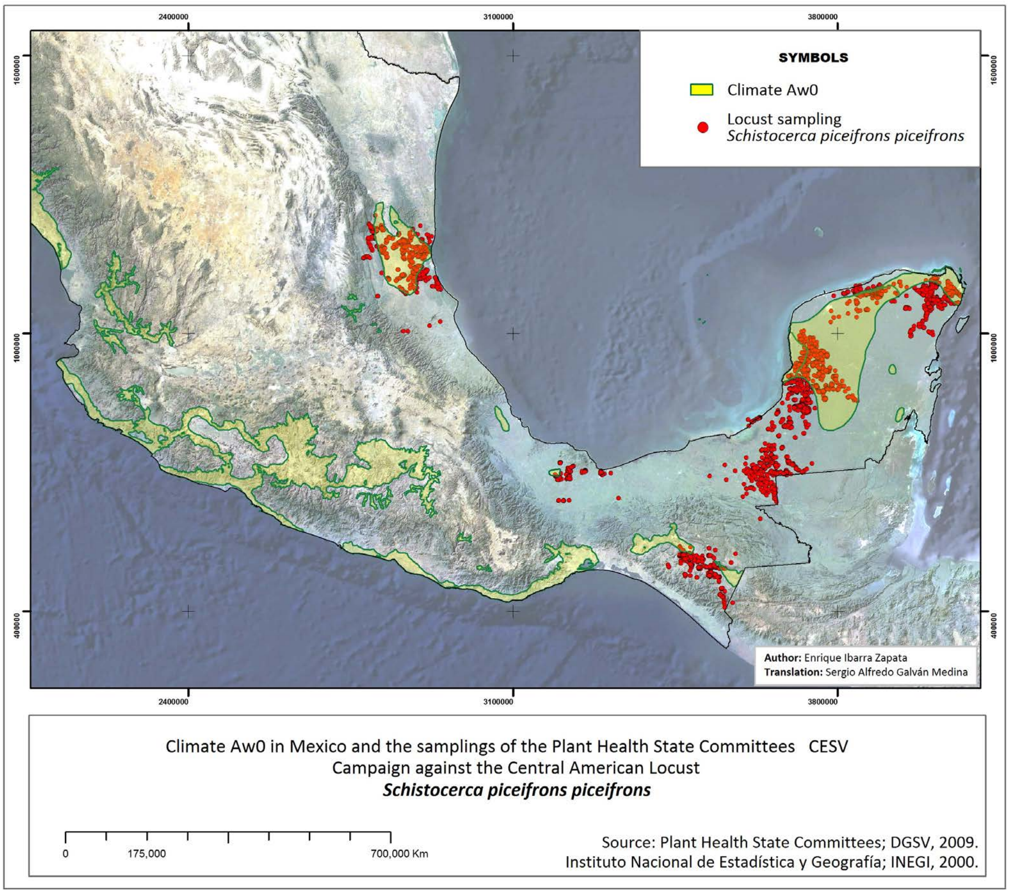


Figure 5. It shows the locust and its relation to climate Aw_0 with information DGSV.

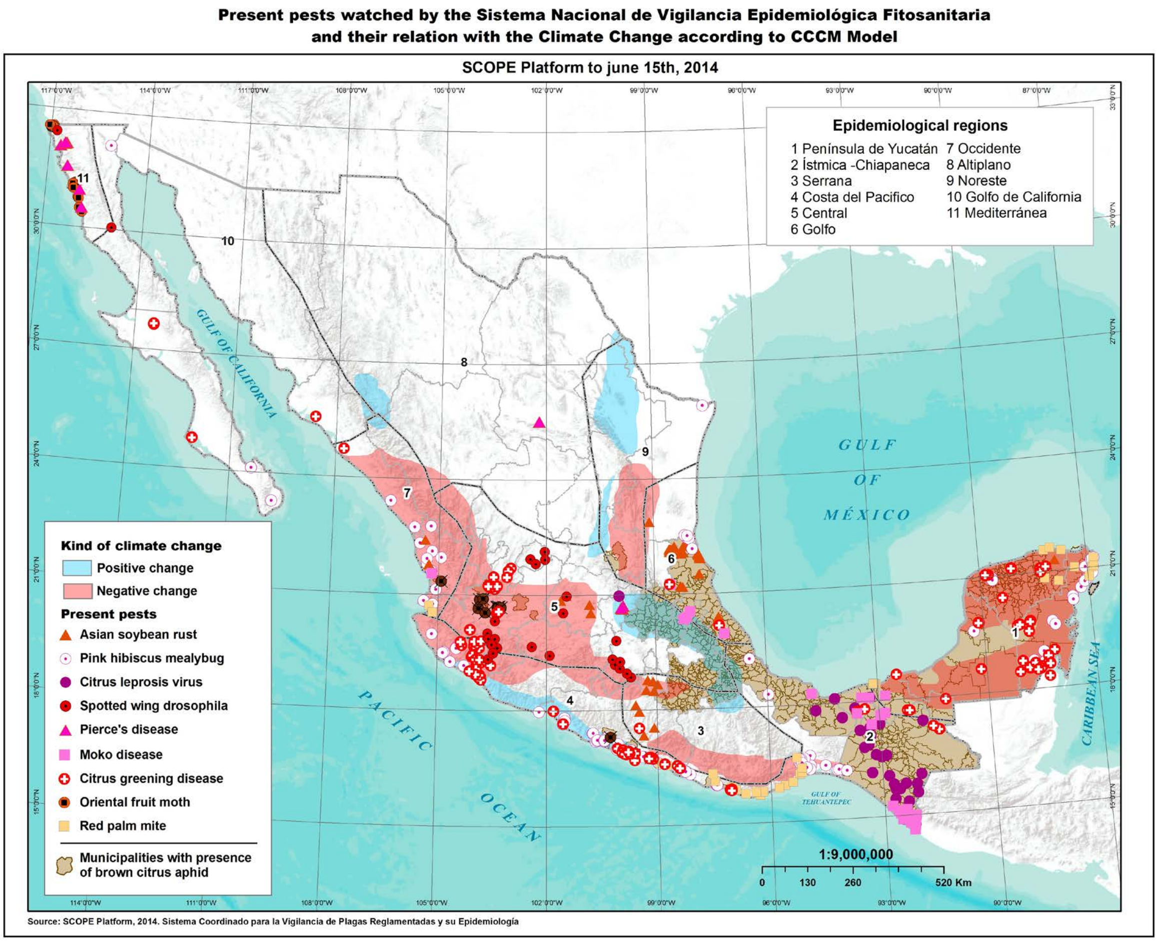


Figure 6. Regions affected by the increase or decrease of meteorological drought. Source: Hernandez, *et al.*, 2000.

and the Pacific Ocean. These ideas have been implemented to demonstrate the SINAVEF as global prediction model El Niño coincides with a greater number of pests. Preceding studies show that climate change is modifying the distribution of pests and plant diseases, and therefore, it is difficult to predict all the effects of this change.

However, we can say that the prolonged drought and the steady increase of temperatures, like other phenomena of global warming (cyclones and north winds, more intense), favor generally to insect species that are invasive (border) more that native and established, are as adapted to greater extremes of temperature and therefore show a greater ecological plasticity; similarly, some species of phytophagous insects are pests or not, that will increase while others weaken or reduce their development, but the net effect is increased pest pressure on crops. In **Figure 6**, depending on model CCC (Canadian Climate Center) focused on meteorological drought, we can see that for the years 2025-2050, presents a scenario where that drafts subhumid climates (Aw) is seen period dry months will increase and probably some regions have a semi-arid climate (BS), which should promote an environment where agricultural pests would increase by decreasing the number of days with rain (**Figure 5**).

Finally it can be concluded that it is necessary to better understand the ecology of pests and their hosts, not only the correlations between them, in addition to improving climate modeling and its consequences, to prioritize risks and improve the reliability of predictions and scenarios in the future.

References

[1] Pataki, E. (1972) Conceptos fundamentales de ecología. Capitulo I y II. Ed. CENIC (La Habana). 38 p.

[2] Petzoldt, C. and Seaman, A. (2006) Climate Change Effects on Insects and Pathogens. *Climate Change and Agriculture*: *Promoting Practical and Profitable Responses*, **3**, 6-16. http://www.climateandfarming.org/clr-cc.php

[3] Mejia, M. (2005) Calentamiento global y la distribución de plagas. Boletín de la NAPPO, Ontario, 5-6.

[4] Galindo Mendoza, G., Contreras Servín, C. and Ibarra Zapata, E. (2013) La plaga de la Langosta Centroamericana Schistocerca piceifrons piceifrons (Walker). Una visión multidisciplinaria desde la perspectiva del desastre fitosanitario en México. UASLP-CIACyT, México.

[5] Food and Agriculture Organization of the United Nations (1997) Convención Internacional de Protección Fitosanitaria. FAO, Roma.

[6] Contreras Servín, C., Galindo Mendoza, G., López Vázquez, H., Ibarra Zapata, E. and Mata Cuellar, F. (2010) El cambio climático y su influencia en las plagas agrícolas. *Entomología Mexicana*, **9**, 239-243.

[7] Contreras Servín, C. (2009) Conexión climática del fenómeno de "El Niño" con la plaga de langosta cetroameicana (*Schistocerca piceifrons piceifrons*, *Walker*) localizada en el estado de Yucatán y la Huasteca Potosina. *Entomología Mexicana*, **8**, 347-351.

[8] Birch, L.C. (1957) The Role of Weather in Determining the Distribution and Abundance of Animals. *Cold Spring Harbor Symposia on Quantitative Biology*, **22**, 203-218. http://dx.doi.org/10.1101/SQB.1957.022.01.021

[9] Elton, C.S. (1975) Conservation and the Low Population Density of Invertebrates inside Neotropical Rain Forest. *Biological Conservation*, **7**, 3-15. http://dx.doi.org/10.1016/0006-3207(75)90027-0

[10] Wallner, W.E. (1987) Factors Affecting Insect Population Dynamics: Differences between Outbreak and Non-Outbreak Species. *Annual Review of Entomology*, **32**, 317-340. http://dx.doi.org/10.1146/annurev.en.32.010187.001533

[11] Contreras Servín, C. and Galindo Mendoza, G. (2009) Implicaciones y consecuencias del cambio climático. Universitarios Potosinos, México, año 5, número 6, UASLP, 4-9.

[12] Legreve, A. and E. Duveiller (2010) Preventing Potential Diseases and Pest Epidemics under a Changing Climate. In: Reynolds, M.P., Ed., *Climate Change and Crop Production*, CABI Publishing, Wallingford, 50-70.

[13] Climatología Fitosanitaria (2014) http://portal.sinavef.gob.mx/portadaClimatologia.html

[14] Instituto Nacional de Estadística y Geografía (2014). http://www.inegi.org.mx

[15] Intergovernmental Panel on Climate Change (2001) Climate Change: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

[16] Hernández, C.M.E., Torres, T.L.A. and Valdez, M.G. (2000) Sequía Meteorológica, 25-40. En: C. Gay (comp.) México: Una visión hacia el siglo XXI. El cambio climático en México. Resultados de los estudios de la vulnerabilidad del país, coordinados por el INE con el apoyo del U.S. Country Studies Program, México: INE, SEMARNAP, UNAM, US Country Studies Program.

[17] García, E. (1988) Modificaciones al sistema de Clasificación Climática de Köppen. Cuarta Edición. UNAM, México, 217 p.

[18] Contreras Servín, C., Mendoza, G. and Zapata, I. (2012) Condiciones climáticas asociadas al establecimiento y dispersión de la Diaphorina citri y la enfermedad del Huanglongbing (HLB) en México. *Entomología Mexicana*, **II-1**, 769-773.

[19] Servicio Meteorológico Nacional (2014) http://smn.cna.gob.com

[20] Graça, J.V. and Korsten, L. (2004) Citrus Huanglongbing: Review, Present status and Future Strategies. In: Naqvi, S.A.M.H., Ed., *Diseases of Fruits and Vegetables Volume I*, Springer Netherlands, Berlin, 229-245.

[21] Sistema Coordinado para la Vigilancia de Plagas Reglamentadas y su Epidemiología (2014). http://www.scopemx.uaslp.mx/

Scientific Research

www.scirp.org

Scientific Research Publishing (SCIRP) is one of the largest Open Access journal publishers. It is currently publishing more than 200 open access, online, peer-reviewed journals covering a wide range of academic disciplines. SCIRP serves the worldwide academic communities and contributes to the progress and application of science with its publication.

Other selected journals from SCIRP are listed as below. Submit your manuscript to us via either submit@scirp.org or Online Submission Portal.