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EFFECT OF CLIMATE CHANGE ON THE RISK OF OCCURRENCE OF MONILIASIS (MONILIOPHTHORA RORERI) OF CACAO IN COMALCALCO, TABASCO, MEXICO

Lorenzo Armando Aceves Navarro
Postgraduate College - Tabasco Campus.
Environment Knowledge Area.
Cárdenas-Huimanguillo highway km 3.5.
H. Cárdenas, Tabasco, Zip code: 86500.
ORCID ID: 0000-0002-9301-9223

Bismarck Álvarez de la Cruz
Postgraduate College-Tabasco Campus.
Cárdenas-Huimanguillo highway km 3.5.
H. Cardenas, Tabasco – Zip code: 86500.

Abstract: The risk of moniliasis infection was determined(*Moniliophthora roreri*) in the main cocoa-producing area of the state of Tabasco and all of Mexico; under two time periods. The first for the period (1965 - 2006) and the second for a climate change scenario of high CO_2 emissions, for a horizon (2015 - 2039). For this, historical data from the period 1965-2006 from the weather station 027009 in Comalcalco, Tabasco were used. And for the horizon (2015 - 2039) average temperature data of 24 years generated by the HADGEM2 model were obtained under a scenario of high CO_2 emissions. The risk of infection for both periods was determined based on the degree of climatic favorability for the disease to prosper and develop, using a classification based on temperature and relative humidity data. When comparing both periods, the results show that under the worst climate change scenario (RCP 8.5), the climatic conditions would be less favorable for the thrush infestation to thrive.
Keywords: *Theobroma cacao, climate favourability, HADGEM2 model*\

INTRODUCTION

Moniliophthora roreri It is the causal agent of cocoa moniliasis (Theobroma cacao L.). This disease, described by several authors as the most destructive of the crop in Latin America (Ortiz-García et al., 2015) can cause losses of more than 75 % of the annual production (Torres-de la Cruz et al., 2011). and even total losses (Torres-de la Cruz et al., 2019). This fungus entered Tabasco through the municipality of Huimanguillo and in less than a year, all the producing areas of the entity were contaminated by cocoa moniliasis (Torres - de la Cruz et al., 2011). The presence, infestation and development of cocoa moniliasis is closely related to the existing climatic conditions of the region (Mora and Fiallos, 2012). The fundamental factors are low temperatures and high relative humidity (Torres - de la Cruz et al., 2011. These authors report that currently in the cocoa-producing areas in the state of Tabasco there are favorable climatic conditions for its development in almost all the year The climate change scenarios developed for Mexico and Central America, where their impacts, vulnerability and adaptation are highlighted, indicate a substantial increase in the average daily temperature (Fernández et al., 2021). It is known that the air temperature has an inverse relationship with the relative humidity, in such a way that, if the temperature increases, the value of the relative humidity decreases. Since the municipality of Comalcalco, Tabasco is one of the most important cocoa-growing municipalities of the entity and the country, The objective of the present work was to find out what would be the answer of *Moniliophyhora roreri*, to the climatic conditions of this climate change scenario in the area of influence of said climatological station and glimpse a future panorama of the disease and its management. For this, one of the 15 General Models of General Circulation of the Atmosphere (MCGA) proposed in the report of the Fifth National Communication of Mexico to the United Nations Framework Convention on Climate Change was selected. The selected model was the HADGEM2 of the United Kingdom, with radiative forcing (RCP) of 8.5 (high CO2 emissions), and a horizon or near future 2015-2039.

MATERIALS AND METHODS

Climatological information and data management. Daily maximum and minimum temperature data (T_{max} and T_{min}) of 42 years of information (1965 - 2006) were extracted from the Comalcalco weather station, Tabasco, from the ERIC III database developed by IMTA, (2009). The extracted data was transcribed into an Excel sheet to facilitate its operational management. From here, the total monthly

averages of the 42 years of registration were obtained, in order to obtain only 12 averages of (T_{med}), one for each month of the year.

Classes of climatic favorability for moniliasis. The climatic favorability classes for the development of moniliasis in each month of the year, were determined using data of mean temperature and monthly average relative humidity and the classification proposed by Moraes et al., 2012 shown in Table 1.

Temperature	Relative humidity	Favorability
22°C – 26°C	> 85%	Very favorable
18°C – 22°C	> 80%	Favorable
26°C – 30°C	> 80%	Favorable
22°C – 26°C	80% - 85%	Favorable
18°C – 30°C	70% - 80%	Relatively favorable
< 18°C o > 30°C	< 70%	Unfavorable

Table 1. Classification of favorable climatic conditions for the development of *Moniliophthora roreri* in cacao. (Según Moraes *et al.* 2012).

Calculation of Relative Humidity. As the Relative Humidity (RH) is not a data that the Eric III provides, it was estimated as a percentage, in terms of the relationship of the partial pressure of the current water vapor between the partial pressure of the water vapor at saturation, with the following equation reported by Allen et al. (1998):

$$HR = \left(\frac{e_a}{e_s}\right) * 100 \quad (1)$$

Where: "e_a" is the partial pressure of the current water vapor (kPa) that for Comalcalco is obtained from the following equation developed by Aceves, (2021):

$$e_a = -1.155 + (0.1778 * T_{min}) \ \ con\ R^2 = 0.99 \quad (2)$$

And "e_s" is the partial pressure of water vapor at saturation (kPa), which is calculated by the following equation, reported by Allen et al. (1998):

$$e_s = 0.61078 * \exp\left[\frac{(17.269 * T_{half})}{(T_{half} + 237.3)}\right] \quad (3)$$

Climate scenario 2015-2039. To determine the favorability of cocoa moniliasis in the near future, one of the 15 General Circulation Models of the Atmosphere (MCGA) proposed in the report of the Fifth National Communication of Mexico to the United Nations Framework Convention on Change was selected. Climate (Fernández et al., 2015). The selected GACM was the UK HADGEM2, with radiative forcing (RCP) of 8.5 (high emissions), a horizon or near future of 2015-2039, and a spatial resolution of 30" x 30" (approximately 926 m x 926 m). which is considered a very complete MGCA. From said scenario and with coordinates similar to those of station 027009 in Comalcalco, Tabasco, the average data of Tmed for 24 years (2015-2039) were collected, from the maps reported for Tabasco by (Fernández et al., 2015). With this, the corresponding HR was calculated, using equations (1), (2) and (3). Immediately afterwards, the Tmed and HR data of the HADGEM2 scenario were used to determine the climatic favorability classes for the monilia, for this scenario, proposals by Moraes et al. (2012).

RESULTS AND DISCUSSION

Figures 1 and 2 show the values of temperature and relative humidity for the period (1965 - 2006) and for the horizon (2015 - 2039) for the area of influence of the weather station 027009 of Comalcalco, Tabasco; that were used to determine the classes of climatic favorability for the monilia in both periods.

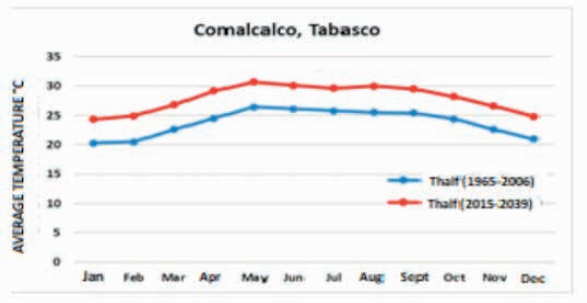

Figure 1. Average temperature of Comalcalco, Tabasco; period (1965 - 2006) (ERIC III) and period (2015 - 2039) (HADGEM2).

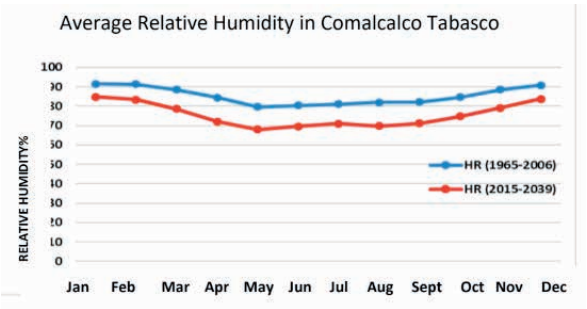

Figure 2. Percentage of relative humidity of Comalcalco, Tabasco; period (1965 - 2006) (ERIC III) and period (2015 - 2039) (HADGEM2).

As observed in Figures 1 and 2, in the horizon climate change scenario (2015 - 2039), an increase in the average daily temperature is expected; associated with a decrease in relative humidity compared to the period (1965 - 2006). The expected temperature increase varies between 4°C to 5°C, with an average value of 4.2°C; while the relative humidity decreases throughout the year between 4% to 12%, with an average decrease of 9.5%.

Table 2 presents the results of the favorability for the occurrence of moniliasis for the area of influence of the weather station 027009 of Comalcalco, Tabasco for the period (1965 - 2006). Then, the data from T_{med} and HR of the HADGEM2 scenario with the climatic favorability classes of Moraes et al., 2012 (Table 1).

	Period 1965 - 2006			Horizon 2015 - 2039		
MONTH	**Temperature (°C)**	**Relative humidity (%)**	**Favorability**	**Temperature (°C)**	**Relative humidity (%)**	**Favorability**
January	20	92	Favorable	24	88	Favorable
February	21	91	Favorable	25	83	Favorable
March	23	88	Very favorable	27	79	Relatively favorable
April	25	84	Favorable	29	72	Relatively favorable
May	26	80	Favorable	31	68	Unfavorable
June	26	80	Favorable	30	70	Relatively favorable
July	26	81	Favorable	30	71	Relatively favorable
August	26	82	Favorable	30	70	Relatively favorable
September	25	82	Favorable	30	71	Relatively favorable
October	24	85	Very favorable	28	75	Relatively favorable
November	23	88	Favorable	27	79	Relatively favorable
December	21	91	Favorable	25	84	Favorable

Table 2. Risk of development of *Moniliophthora roreri* in the area of influence of station 027009 of Comalcalco, Tabasco, according to the favorability classes in the period (1965 -2006).

As can be seen in Table 2, for the period (1965-2006) there is a predominance of favorable months for the development of moniliasis throughout the year with very favorable conditions in the months of March to November. These results agree with what was reported by Moraes et al. (2012) for Brazil, who affirm that in the period (1961-1990), the period of greatest development of moniliasis was between the months of November and May. In contrast, for the HADGEM2 climate scenario period (2015-2039), the risk of moniliasis occurrence decreased in 8 months of the year that were relatively favorable and only the month of May with unfavorable conditions. The rest of the months (December to February) were favorable and did not suffer any change in both periods. Similar results were obtained for Brazil (Moraes et al., 2012), who report a reduction in areas with potential climates for the occurrence of moniliasis in the period (2020 to 2080).

CONCLUSIONS

The climatic conditions of the area of influence of the weather station of Comalcalco, Tabasco; currently presents risk conditions for the development of *Moniliophthora roreri* from favorable to very favorable all year round. The climate change scenario according to the HADGEM2 model, in the near future (2015 -2039), for Comalcalco, as it was for Brazil, is less favorable for the development of the moniliasis disease in cocoa.

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