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Characterization of the Climatic Rankins for Jamaica (*Hibiscus sabdariffa* L.) Crop in Jalisco, México

A. Pérez-González, P. Posos-Ponce, J. Carreón-Amaya, J.L. Martínez-Ramírez,
J.C. Serratos-Arévalo and E. Pimienta-Barrios
Universidad de Guadalajara, CUCBA, km 15.5 Guadalajara, Nogales,
Predio las Agujas, Nextipac, Jalisco, C.P. 45110, Mexico

Abstract: The present research contains the geographical references detailed by municipal including climatic characteristics, marginal areas, optimal and suboptimal areas where Jamaica as an alternative crop represents a viable option for the maintainable development of those regions with climatic limitations for other crops. Based on the reference data it is considered 125 humidity days as the optimal to develop the crop. In Jalisco 900,000 ha has been reported with this condition within the nine climatic zones existing.

Key words: Weather maps, global positioning system, Jamaica, Jalisco-Mexico

INTRODUCTION

The cultivation of Jamaica (*Hibiscus sabdariffa* L.) is an alternative that is presented to agricultural low tech growers in Jalisco, México, but for being a little-known crop, it is necessary to conduct studies related to the climatic requirements for its establishment and profitability as a possible alternative crop, because Mexico has producers with little land about 1 or 2 ha. Those growers and their families make by hand all the field work, so, with this research it will be possible to cultivate Jamaica in remote areas, where people don't have other option of cultivation. (SAGARPA, 2004). For the last reason the objective of this research is to characterize regional sites in which to establish Jamaica and further characterize the stages that present this crop. This research contains standardized information that resulted in seven climatologically parameters: classification of climates, growing season, annual maximum temperature, medium and minimum, relative humidity and annual rainfall. The characterization of these parameters was performed in 116 meteorological stations for the monitoring of the National Water Commission (2000).

MATERIALS AND METHODS

The weather characterization was conducted in the state of Jalisco, México which has a territorial extension of 7'889071 ha and has borders with the North Zacatecas, the Northwest with Nayarit, with the Northeast

Aguascalientes, San Luis Potosí and Guanajuato, East Michoacán, South Colima and the Southeast to the Pacific Ocean (INEGI, 2000).

Field mapping and geo-referenced: The map on which were the source Stroke is the Charter of the State of Jalisco developed by the Institute of Geography of the UNAM and the Department of State Planning and Development (Villalpando and Garcia, 1993). The methodology consisted of recovering data on collections that were made during the years 2003, 2004 and 2005 from different species of Jamaica that were found in the state of Jalisco. It was subsequently validated information concerning the geographical coordinates of each collection site. This was done partly through field visits to georeferenced with a GPS GARMIN XL-12. However, information was revised coordinates primarily through means such as geographical reference Atlas of Microsoft Encarta and Gazetteer of the State Geographical Summaries of the National Institute of Statistics and Informatics (INEGI, 2000).

Once you have made these activities, joined an array of geo-referenced data for Jamaica crop, compiled in microsoft excel in the program and ISDRISI containing the following information: kind, town, municipality, longitude, latitude, altitude and height above sea level.

RESULTS AND DISCUSSION

Ruiz *et al.* (1999) indicated that the temperatures of Jamaica crop needs are in the ranging between 25 and

Table 1: Potential areas for the establishment of Jamaica crop, in relation to the Station growth in the state of Jalisco

Zone	Days of wet period	State percent of the area	Surface (ha)
Not suitable	80-95	5.43	438,372
Marginal	95-110	33.83	2,669,000
Suboptimal	110-125	49.38	3,895,000
Optimal	125-140	11.21	884,000
Optimal	140-155	0.15	11,833

Table 2: Temperatures of cultivation of Jamaica crop, in experimental plots in the state of Jalisco

Fenological stage	Tb	To	Tu
	----- (°C) -----		
Sowing	10	12	9.2
Emergency	11	12	9.2
1st true leaf	12	14	16.0
Flower bud	14	16	21.0
Flowering	14	16	26.0
Opening chalice	19	21	29.0
Maturity to cut trade	19	27	32.0

Tb: Temperature basic, To: Optimum temperature, Tu: Temperature threshold

29°C to be established under optimum conditions. In addition it was found that day had a wide variation in temperatures average day/night, which resulted in five different geographical areas. However two geographical areas of the five reported are potentially suitable to crop establishment of Jamaica (Table 1), which coincides with López *et al.* (2004), who points out that the state of Jalisco is a wide range of geographic areas, which may set different crops. As it was indicated Ruiz *et al.* (2003) in relation to the growing season (wet period) is necessary territorial classification of a region for study, so that the data was classified in 5 regions with a minimum of 80 and 155 days maximum. The bioclimatology was the result of the implementation of statistical information on weather physiology and productivity of Jamaica, where according to Núñez (2003), the ecological niche of Jamaica ranges from 120 to 150 days, therefore only 2 regions may be potentially suitable for the establishment of this crop.

The cardinal temperatures obtained for different stages were recorded at the beginning, the middle and end of each one of the manifestations of the stages, through a higrothermograph, in eight batches in different pilot municipalities of the state, during the years 2003, 2004 and 2005 (Table 2).

The comments were made in locations of study, as well as statistical information and data from other authors helped develop the weather maps that characterize the state of Jalisco.

The map, which characterizes the climate ranges obtained, is for the different climates that are filed with the state of Jalisco, according to the classification proposed by Ruiz *et al.* (1999) as follows:

A is warm weather B is cold weather, climate and C is temperate weather, which is shown in Fig. 1.

According to what is observed in Fig. 1, B weathers (cold) no conditions for the development of Jamaica crop, under which those temperatures inhibit the development and maturity of the crop. The top A (warm) and together with the climate A (C) (warm with a tendency to temperate) represents regions: South Coast and North Coast; Regions Cienega, Southeast and South; Sierra Amula, Valleys, Sierra West and Central Sierra, are the optimal areas for the establishment of this crop. In relation to areas C (A) (tempered with a tendency to warm) and C (mild) are considered within the optimum range and suboptimal, so it follows that in the state of Jalisco there is great potential for establishing Jamaica crop.

This coincides with those reported in the INIFAP (2002), which define what the needs or requirements are usually described by ranks and often reported by species and even by genotype and that in relation to these ranges, the ranges can be singled out for adaptation and of course the optimum, suboptimo and marginal adaptation of any plant species.

According to Fig. 2, in the state of Jalisco were marked five different stations that growth is a variation from 80 to 155 days, which indicates a significant difference for the 12 regions that make up the state. The area 95 days of wet period is located at the North end of the state and is considered marginal, it remains the north with 110 days in the same way marginal and is in the Central region Valleys, North Coast and South Coast, where they start finding conditions for the establishment of the crop of Jamaica, but are considered suboptimal areas, however for the establishment of this crop, can be found two areas potentially best with a growing season that ranges between 125 and 155 days, In the municipalities of Tomatlán, La Huerta, Purification, Pihuamo, Concepcion de Buenos Aires, Manzanilla of Peace, Mazamitla, Cabo Corrientes, Talpa de Allende, Mascota, Villa Corona, Casimiro Castillo. What coincides with Villalpando and García (1993), who point out that the state of Jalisco there is great potential for establishing crops subtropical climate and temperate climate, such as the cultivation of Jamaica crop.

Another important factor for the adaptation of a crop is the relative humidity, as shown in Fig. 3.

According to Salisbury *et al.* (1994), the water content in the air is called relative humidity is defined as the percentage of saturated air with water moisture, is the relationship between the amount of water moisture containing a cubic meter air in certain conditions of temperature and pressure and would have if it was

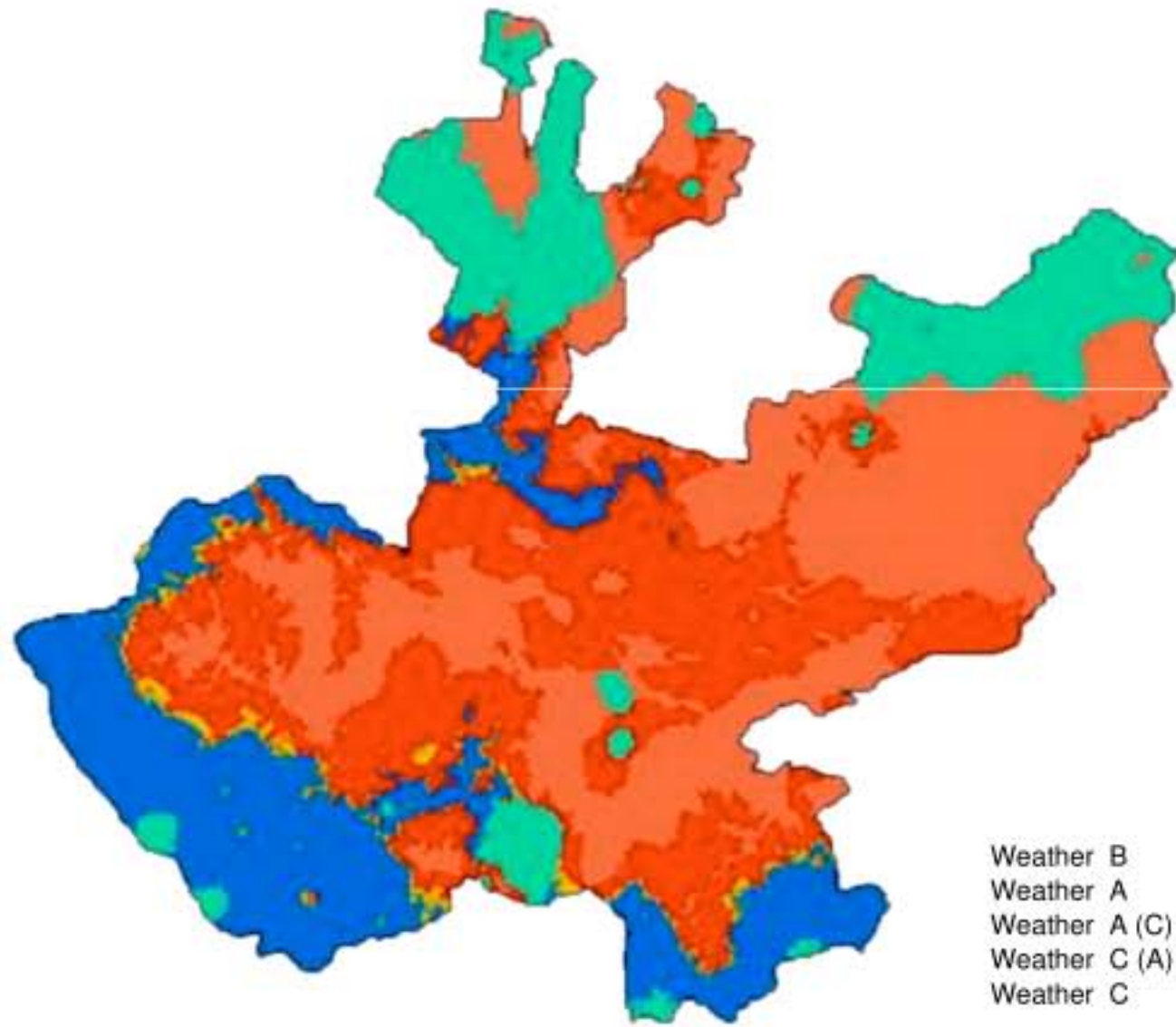


Fig. 1: Weather classification in Jalisco, México

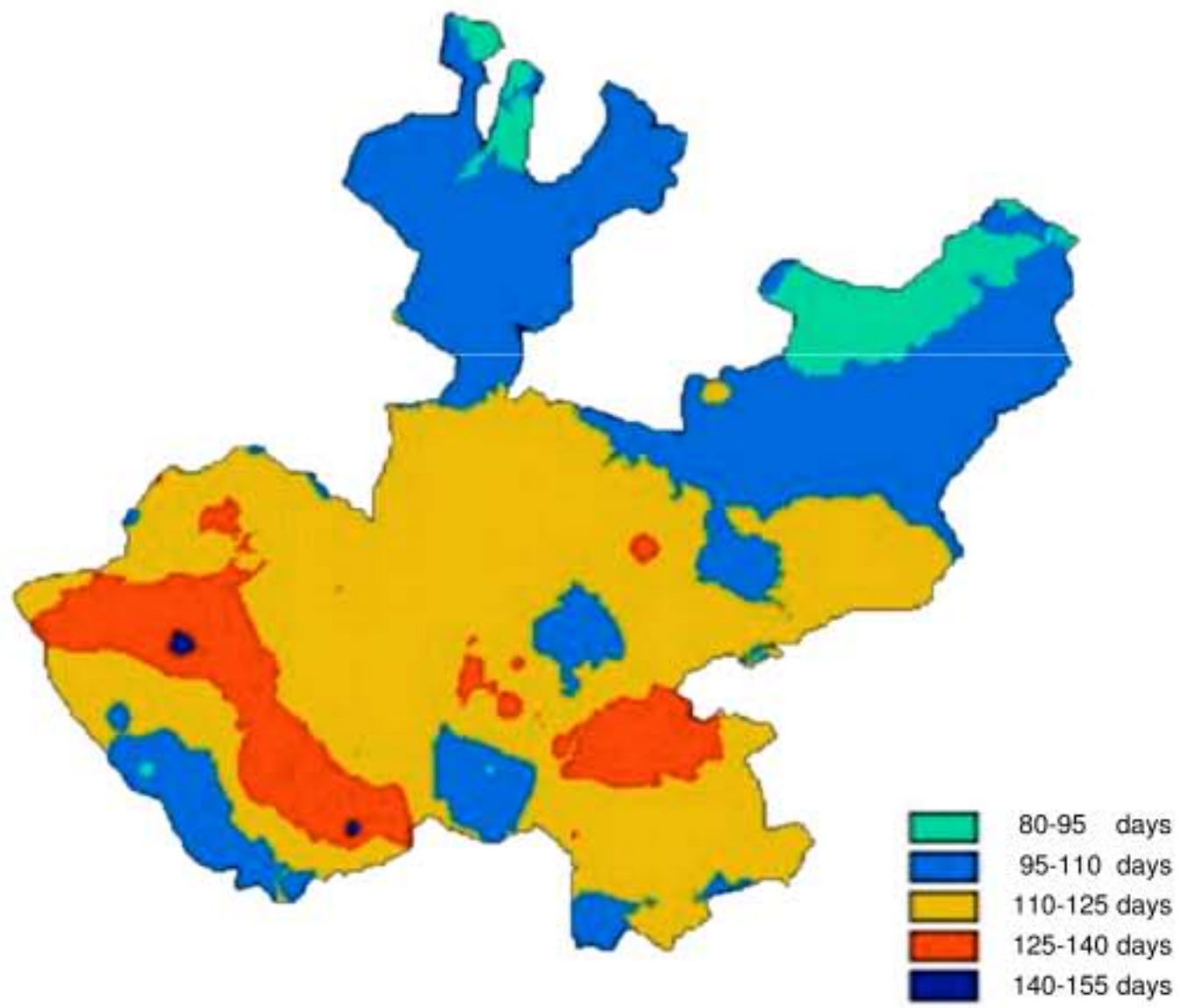


Fig. 2: Classification station growth

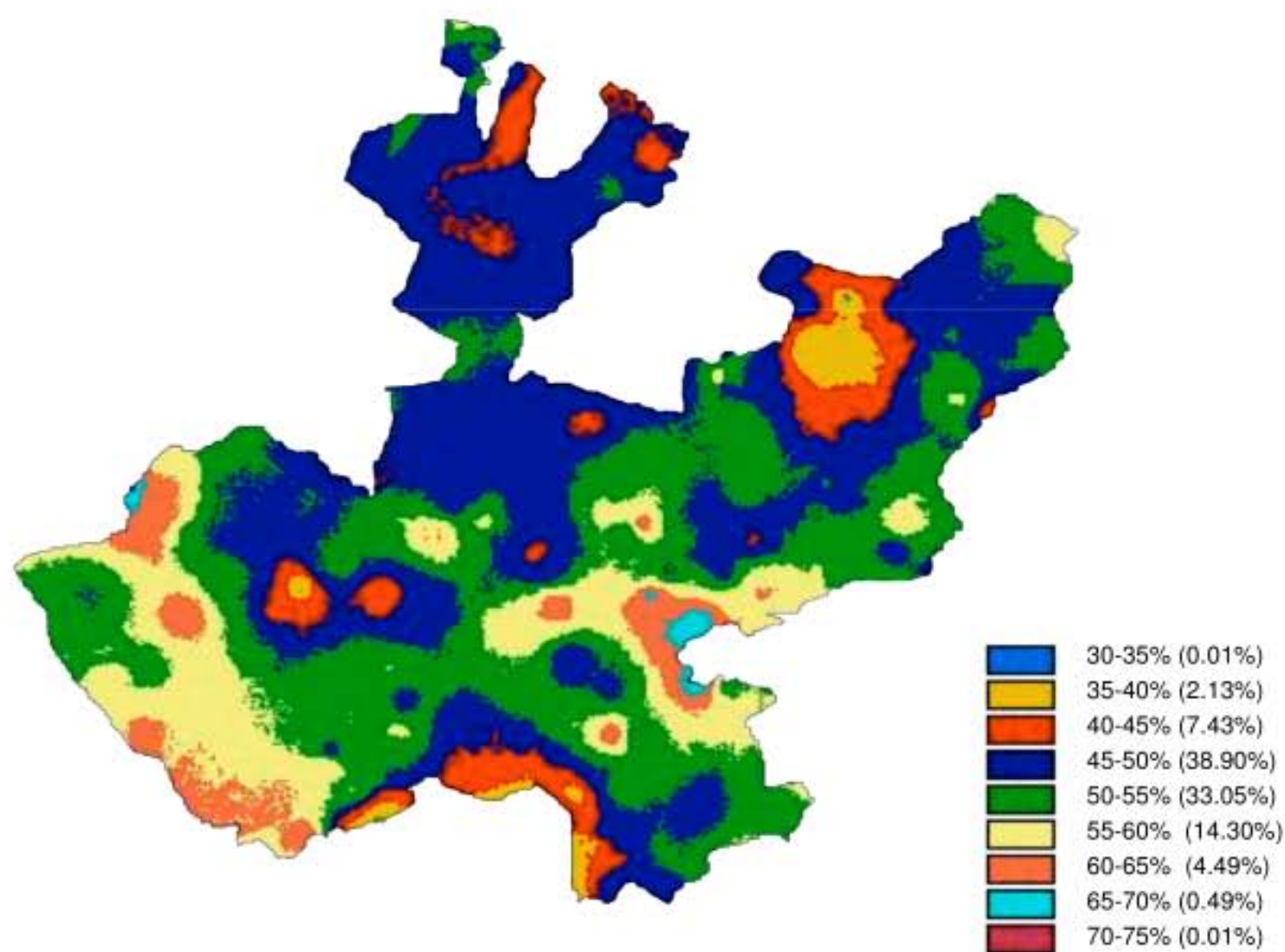


Fig. 3: Relative humidity

saturated at the same temperature and pressure. Referring to Fig. 3, nine strata are duly regionalized characterized by its content and relative humidity. The municipalities that have the highest rate of relative humidity and representing 71.95% of the area of State are: Talpa de Allende, Atenguillo, Ayutla, Cuautla, Union de Tula, Casimiro Castillo, Autlán, San Sebastian del Oeste, Mascota, Guachinango, Jalisco, San Gabriel, Tuxcacuesco, Manuel M. Dieguez, Tamazula de Gordiano, Mazamitla, Jilotlán, Quitupan, Degollado, Jesus Maria, Poncitlán, Ocotlán, Jamay, La Barca, Ixtlahuacan, Chapala, Jocotepec, Villa Corona, Atemajac de Brizuela, Tapalpa, Chiquilistlán, Juchitlán, Tenamaxtlán, Tecolotlán, Acatlan Juarez, Cocula, San Martin Hidalgo and Tecalitlán among others.

In Fig. 4, six layers have been marked ranging from (-) 5 to 25°C as the minimum temperature, so only three strata can be considered in establishing the cultivation of jamaica, under which requires as jamaica basic minimum temperature 10°C. The municipalities most representative of this section are: Ayotlan, Atotonilco, Tototlan, Atotonilco, Degollado, Zapopan, Amatitan, Magdalena, San Marcos, Etzatlán, Teuchitlán, Tlajomulco de Zuniga, Acatlan, Juarez, Ameca, Guachinango, Jalisco, San Sebastian West, Puerto Vallarta, Mascota, Atenguillo, Mexicacán, stick, Mixtlán, Tecolotlán, Atemajac de

Brizuela, Zacoalco Torres, Atoyac, Concepcion de Buenos Aires, Villa Corona, Amacueca, Chiquilistlán, Tenamaxtlán, Talpa de Allende, Cabo Corrientes, Tomatlán, Ayutla, Cuatla, Ejutla, Purification, la Huerta, Casimiro Castillo, Cihuatlan, Venustiano Carranza (San Gabriel), Zapotitlan de Vadillo, Tonila, Tuxpan, Pihuamo, Tecalitlán, Jilotlan of Sorrows, Manuel M. Dieguez, Manzanilla de la Paz, El Limon, Mazamitla, Ocotlán, Poncitlán, Quitupán, San Cristobal de la Barranca, Sayula, Tala, Tamazula de Gordiano, Tequila, Ciudad Guzman (Zapotlán the Great), Tizapan Upper and Zapotitlan de Vadillo between others. In this rubric, six layers have been marked ranging between 10 to 40°C as the maximum temperature, but only three stratum can be considered in establishing the cultivation of Jamaica crop, since this crop requires temperatures above 25°C.

In Fig. 5, we observe the municipalities most representative of this section are: Ayotlán, Atotonilco, Tototlan, Atotonilco, Degollado, Zapopan, Amatitan, Magdalena, San Marcos, Etzatlán, Teuchitlán, Tlajomulco de Zuniga, Acatlan, Juarez, Ameca, Guachinango, Jalisco, San Sebastian West, Puerto Vallarta, Mascota, Atenguillo, Mexicacán, stick, Mixtlán, Tecolotlán, Atemajac de Brizuela, Zacoalco Torres, Atoyac, Concepcion de

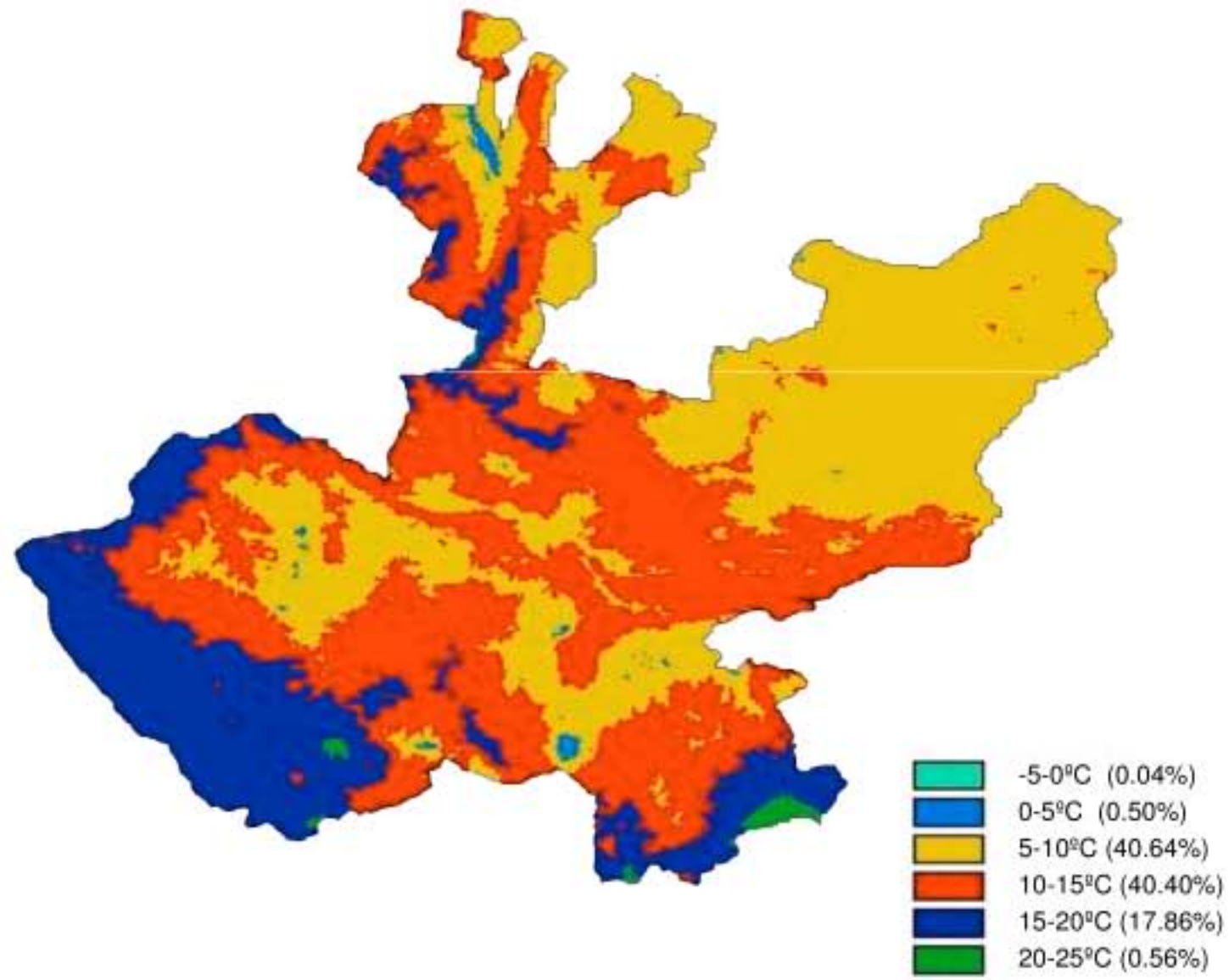


Fig. 4: Minimum temperature annual

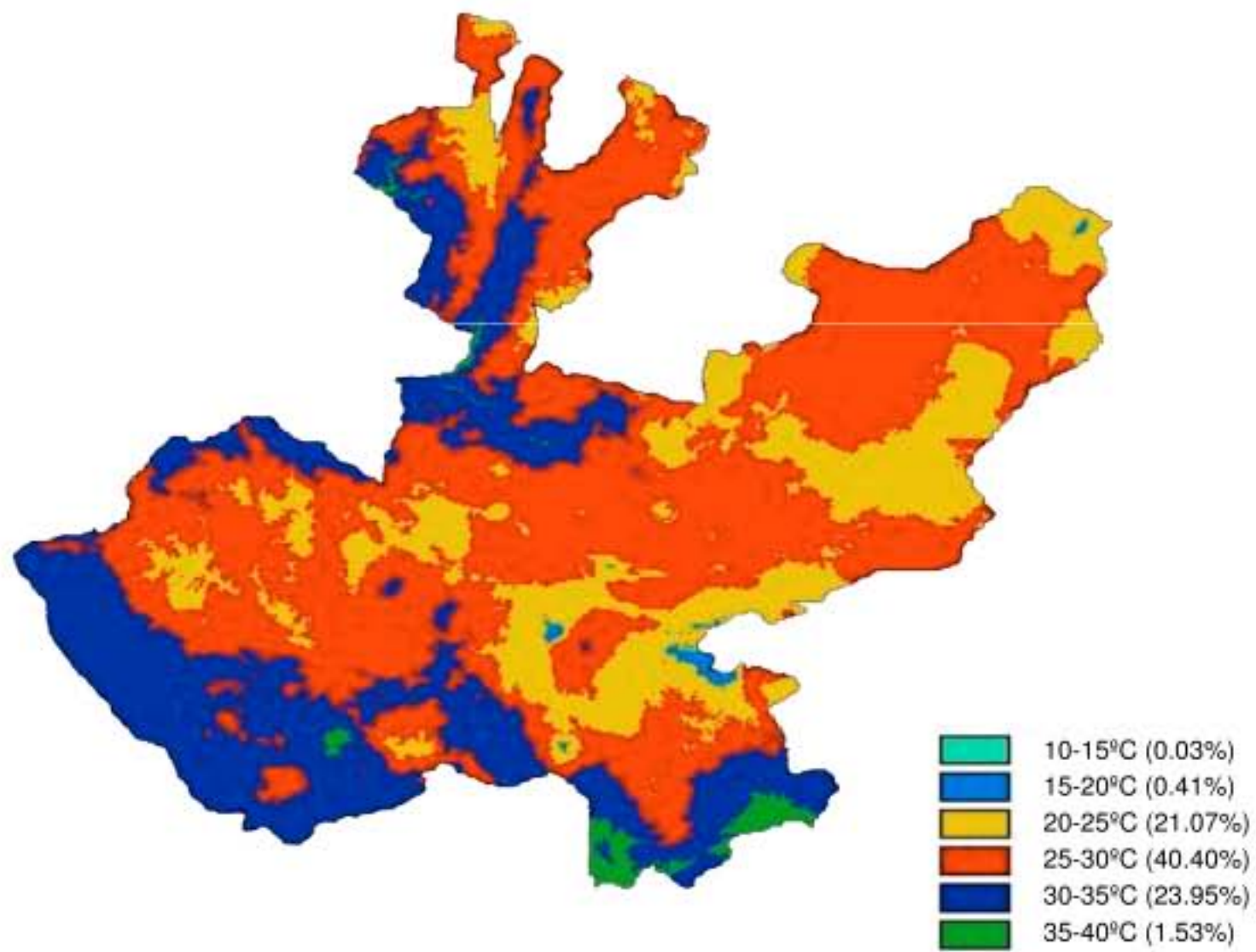


Fig. 5: Maximum temperature annual

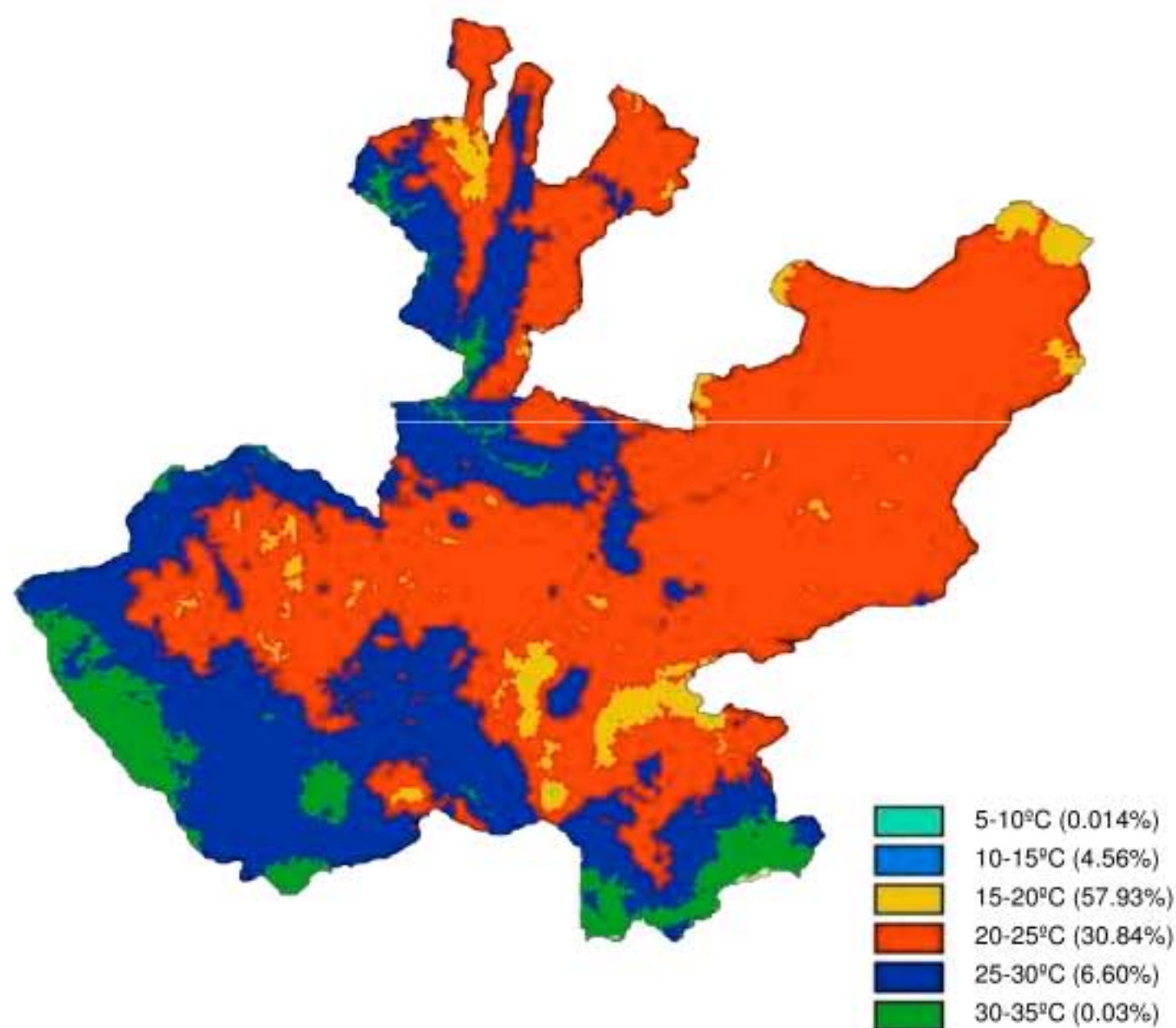


Fig. 6: Annual average temperature

Buenos Aires, Villa Corona, Amacueca, Chiquilistlán, Tenamaxtlán, Talpa de Allende, Cabo Corrientes, Tomatlán, Ayutla, Cuatla, Ejutla, Purificación, la Huerta, Casimiro Castillo, Cihuatlan, Venustiano Carranza (San Gabriel), Zapotitlan de Vadillo, Tonila, Tuxpan, Pihuamo, Tecalitlán, Jilotlan of Sorrows, Manuel M. Dieguez, Manzanilla de la Paz, El Limon, Mazamitla, Ocotlán, Poncitlán, Quitupán, San Cristobal de la Barranca, Sayula, Tala, Tamazula de Gordiano, Tequila, Ciudad Guzman (Zapotlán the Great), Tizapan Upper and Zapotitlan de Vadillo between others.

According to Fig. 6, six layers were characterized ranging between 10 to 40°C as the maximum temperature, but only three strata can be considered in establishing the cultivation of jamaica, since this crop requires temperatures above 25°C. The municipalities most representative of this section are: Ayotlán, Atotonilco, Tototlan, Atotonilco, Degollado, Zapopan, Amatitan, Magdalena, San Marcos, Etzatlán, Teuchitlán, Tlajomulco de Zuniga, Acatlan, Juarez, Ameca, Guachinango, Jalisco, San Sebastian West, Puerto Vallarta, Mascot, Atenguillo, Mexxicacán, Mixtlán, Tecolotlán, Atemajac de Brizuela, Zacoalco Torres, Atoyac, Concepcion de Buenos Aires, Villa Corona, Amacueca, Chiquilistlán, Tenamaxtlán,

Talpa de Allende, Cabo Corrientes, Tomatlán, Ayutla, Cuatla, Ejutla, Purificación, la Huerta, Casimiro Castillo, Cihuatlan, Venustiano Carranza (San Gabriel), Zapotitlan de Vadillo, Tonila, Tuxpan, Pihuamo, Tecalitlán, Jilotlan of Sorrows, Manuel M. Dieguez, Manzanilla de la Paz, El Limon, Mazamitla, Ocotlán, Poncitlán, Quitupán, San Cristobal de la Barranca, Sayula, Tala, Tamazula de Gordiano, Tequila, Ciudad Guzman (Zapotlán the Great), Tizapan Upper and Zapotitlan de Vadillo between others.

According to Fig. 7, five strata were marked ranging between 5 to 30°C as maximum temperature, but only three strata can be considered in establishing the cultivation of Jamaica crop, since this crop requires annual average temperatures between 15 and 30°C.

The municipalities most representative of this section are: Ayotlán, Atotonilco, Tototlan, Atotonilco, Degollado, Zapopan, Amatitan, Magdalena, San Marcos, Etzatlán, Teuchitlán, Tlajomulco de Zuniga, Acatlan, Juarez, Ameca, Guachinango, Jalisco, San Sebastian West, Puerto Vallarta, Mascota, Atenguillo, Mexxicacán, Mixtlán, Tecolotlán, Atemajac de Brizuela, Zacoalco Torres, Atoyac, Concepcion de Buenos Aires, Villa Corona, Amacueca, Chiquilistlán, Tenamaxtlán, Talpa de Allende,

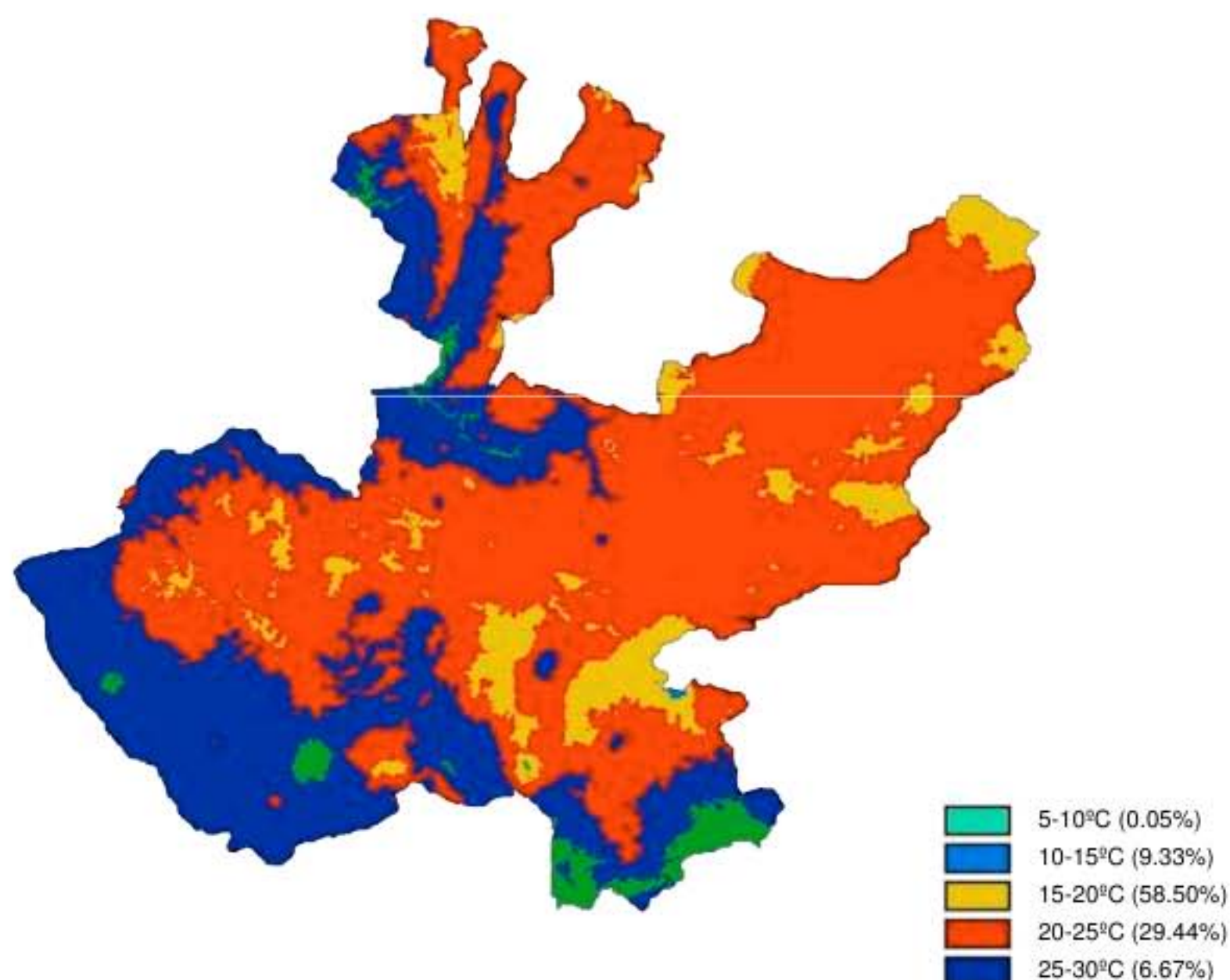


Fig. 7: Annual daytime temperature

Cabo Corrientes, Tomatlán, Ayutla, Cuatla, Ejutla, Purificación, la Huerta, Casimiro Castillo, Cihuatlan, Venustiano Carranza (San Gabriel), Zapotitlan de Vadillo, Tonila, Tuxpan, Pihuamo, Tecalitlán, Jilotlan of Sorrows, Manuel M. Dieguez, Manzanilla de la Paz, El Limon, Mazamitla, Ocotlán, Poncitlán, Quitupán, San Cristobal de la Barranca, Sayula, Tala, Tamazula de Gordiano, Tequila, Ciudad Guzman (Zapotlán the Great), Tizapan Upper and Zapotitlan de Vadillo between others.

According to the Fig. 8, six strata were recognized in annual temperature night, but the area is compact in only two layers that together account for 85.16% of the state and a thermal oscillation between 10 and 20°C. The temperature is a factor which influences the climate adaptation of plant species, so it becomes an important variable in the process of diagnosis of potential areas for crops. As such perceive Ruiz *et al.* (2003), the cultivation of Jamaica crop has photoperiod in response to the light step, however the answer to the dark phase has not been named as a promoter or a limiting factor for the development of this crop. The municipalities most representative of this condition are those reported in the detailed description of the Fig. 8.

One of the most important variable for determining ranges climate course is the rainfall, as stated in the, which mentions the importance of making a determination of the spatial distribution of rain according to the strata who are presented with the aim of being able to characterize a region climatically.

This is the case of Fig. 9, which presents 10 layers ranging from 450 to 1950 mm, however precipitation more compact is located in three layers, which have a combined value of 74.30% of the state, ranging from 600 and 1050 mm of rainfall annually. The municipalities most representative of this condition are those reported in the detailed description of the Fig. 9. These values found for the establishment of Jamaica, agree to what was stated by Ruiz *et al.* (2003), who state that this crop requires at least 500 mm of rain, spread over four months at the station wet period.

According to Fig. 10, which is listed below the five areas that were marked for the establishment of Jamaica, were obtained by interpolation of the different variables involved in this study and agrees with Ruiz *et al.* (1999), who points out that Jamaica is a crop that requires at least 125 days for their production. Referring to the results

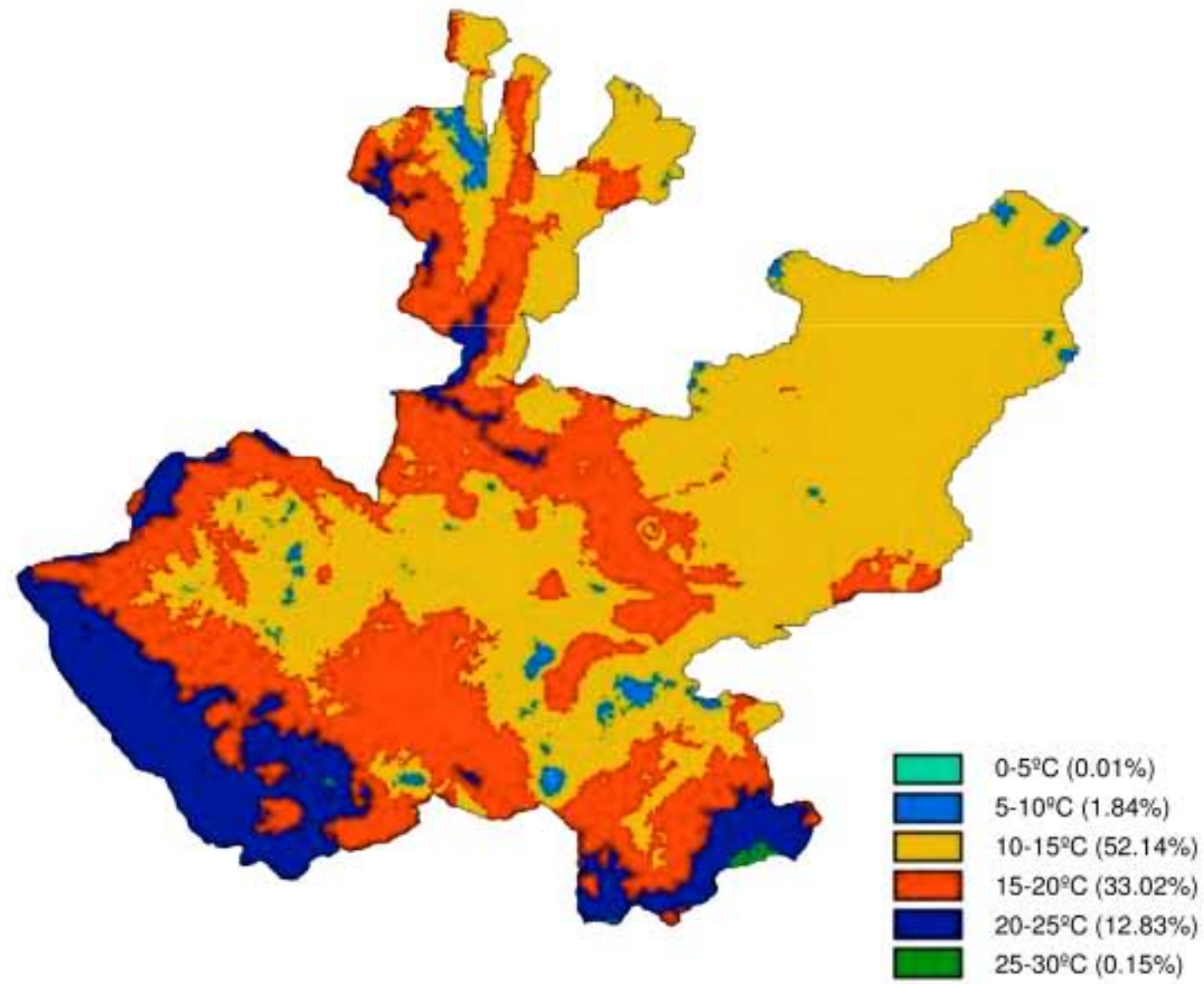


Fig. 8: Temperature annual nocturnal

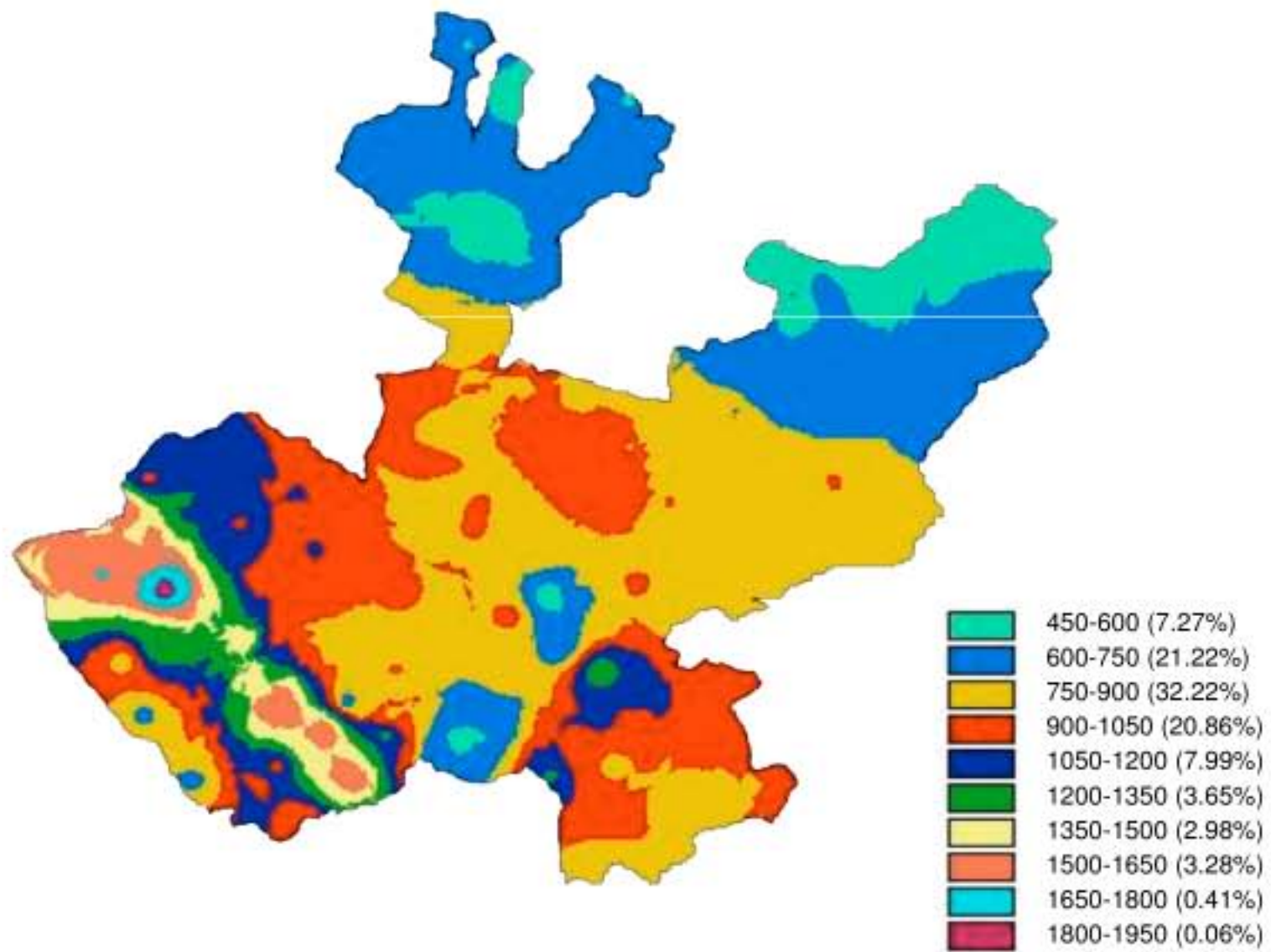


Fig. 9: Annual rainfall (mm year⁻¹)

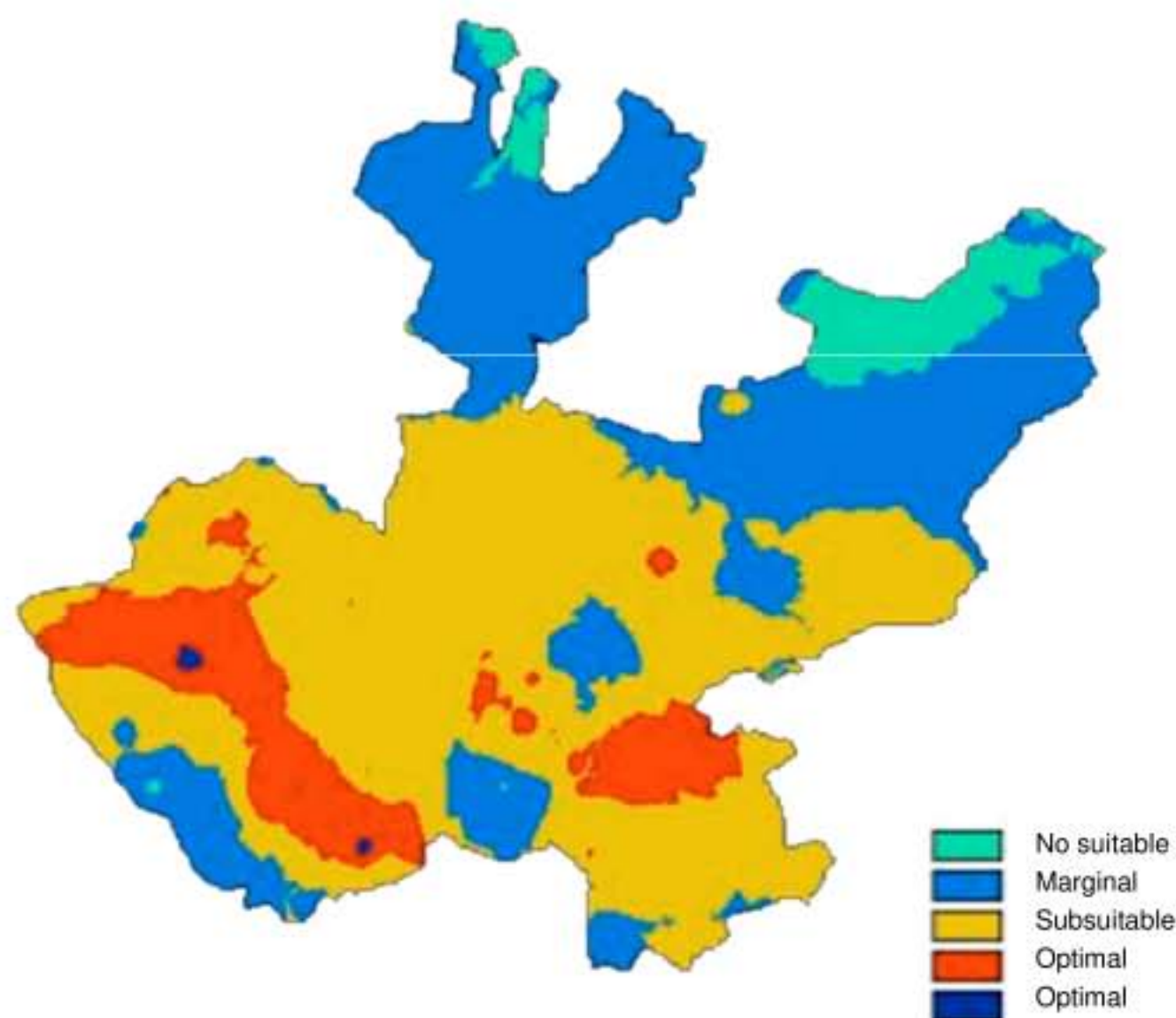


Fig. 10: Characterizing the potential areas for Jamaica crop

found an area unfit and other marginal situation that excludes strictly for cultivation. Moreover suboptimal this area is bounded on the date of planting, as this should not exceed the July 15, in order to avoid an early frost, while the two best areas can be sown until July 30. This coincides with the point made by Salisbury *et al.* (1994), who point out that the process of regionalization climate and the response of plant growth at the temperature is a procedure where by identifying suitable environments suitable for crops.

CONCLUSIONS

The Jamaica *Hibiscus sabdariffa* L. is a kind suitable for tropical and subtropical climates, thermal regime of mild to warm, conditions that occur in some municipalities in the state of Jalisco. The cardinal temperatures estimated for planting should be above 10°C, which tells us that it is not possible to sow during winter as this stops the germination and maturation. Agrees to their development with temperatures typical of most tropical and subtropical crops of 25°C average. For the state of Jalisco there is a potential area of approximately 890000 ha optimal covering mainly the municipalities of the North Coast, South Coast Region Valleys, Cienega Region and Central Region.

The jamaica presents six stages, perfectly defined, so that appointments can be made in relation to each of them.

At FAO (1981) reported the agro-climatic conditions for the production of tropical and subtropical crops between 500-1000 m in height, which is not fulfilled for this region, under the proposed change showed that crop up in areas with 1650 m above sea level.

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