

## **SOIL AND CLIMATE CHARACTERIZATION OF THE AVOCADO-PRODUCING AREA OF MICHOACÁN, MEXICO**

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The agro-climatic variables of 22 municipalities are described in the present paper. The results indicate that 71% of orchards correspond to small property, 24% ejido and 5 % communal. The farm areas vary from less than 5 ha to more than 30 ha. The distribution of the area according to optimum conditions reaches 77% with regard to altitude; 76% to maximum temperature, and 60% to minimum temperature. The period with absence of cold temperatures corresponds to 17%, while 9% of these areas are under risk. In relation to heat units, 76% are under the optimum conditions. Regarding precipitation, evaporation and relative humidity, cultivation requirements are satisfied in 100% of the areas. As for soil, 86% of the orchards are in Andosols, considered as the best. In relation to the slope, 88% of the orchards are under good conditions (slopes below 15%). The agro-environmental conditions favor an excellent growth and yield of trees during the whole year. It is worth mentioning three types of weather: (A)C(w2)(w), semi-warm sub-humid, the most humid, in an altitude ranging from 1,600 to 1,800 masl; (A)C(w1)(w), semi-warm sub-humid, between 1,200 and 1600; and C(w2)(w), mild sub-humid climate between 1,900 to 2,300 masl. These conditions have favored a great advance of the avocado with a displacement of areas with forest vocation lands in 20% of the area; this figure represents the growth of the avocado-producing area to the detriment of the natural resources of the region.

Key words: Plantations, distribution, soil, climate, productivity.

## **CARACTERIZACIÓN EDAFOCLIMÁTICA DEL ÁREA PRODUCTORA DE AGUACATE DE MICHOACÁN, MÉXICO.**

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Se describen las variables agroclimáticas de 22 municipios. Los resultados indican que el 71 % de las huertas son pequeña propiedad, el 24 % ejidales y el 5 % comunales. El tamaño de los predios varía desde menos de 5 ha hasta más de 30 ha. La distribución de la superficie por condiciones óptimas, se ubica en el 77 % con respecto a la altitud, 76 % a temperatura máxima, y 60 % para temperatura mínima. El periodo libre de heladas, corresponde al 17 % y en el 9 % de la superficie existe riesgo. En relación a las unidades de calor, el 76 % se

encuentran en lo óptimo. Respecto a precipitación, evaporación y humedad relativa, en el 100 % del área, se satisfacen los requerimientos del cultivo. En cuanto al suelo, el 86 % de los huertos están en Andosoles, considerado el mejor. En relación a la pendiente, el 88 % de los huertos está en condiciones óptimas (pendientes menores del 15 %). Las condiciones agroambientales propician un desarrollo favorable del árbol y la obtención de fruto casi todo el año. Destacan tres climas que son: (A)C(w<sub>2</sub>)(w), semicálido subhúmedo, el más húmedo, en una altitud de 1,600 a 1,800 msnm; (A)C(w<sub>1</sub>)(w), semicálido subhúmedo, de 1,200 a 1600, y C(w<sub>2</sub>)(w), templado subhúmedo, de 1,900 a 2,300 msnm. Estas condiciones han propiciado un gran avance del aguacate con un desplazamiento de áreas de vocación forestal en el 20 % de la superficie. Esta cifra plasma el crecimiento que ha tenido la franja aguacatera en perjuicio de los recursos naturales de la región.

Palabras clave: Plantaciones, distribución, suelo, clima, productividad.

## INTRODUCTION.

The agro-environmental conditions prevalent in the Michoacan avocado producing area propitiate development of the tree and the fruit obtaining in practically the whole year, as well as an it shovels continuous of the different phenological phases of the tree, it mainly certain for the stratum altitudinal as well as the topological arrangement of the plantations with regard to their exhibition in the sun, the slope and the prevalent address of the wind.

The productivity of the cultivation in this wide range of conditions depends on a group of factors, some more or less bound with the characteristic agro-environmental of the orchards. The drop natural fertility of the derived floors of ashy volcanic in which is developed more than 85% of the avocado orchards, it is compensated with the constant and systematic use of chemical and organic fertilizers, which provide the essential nutriments for the fruit-bearing one. However, uncontrollable factors of the climate like icy, hail and strong winds, they can be as restrictive of the production as controllable handling factors so important as the nutrition and the water. In a parallel way, the presence of plagues is bound directly to climatic factors as precipitation, relative humidity, temperature and, to the phenology of the cultivation (Anguiano et al., 2004). On the whole, these biotic and non-biotic factors reduce the productivity of the orchards and the quality of the fruit, maintaining the current standards of productivity in an average of 9.8 fruit rhyme for hectare and around 26% in the quality for the international markets.

Altitude. Benacchio (1982) and Ruíz et al (1999) pointed out that depending on the race of origin of the avocado, this can settle down from the level of the sea until the 3,000 m of altitude, although in the practical orchards to more than 2,400 m they are considered outside of the appropriate area for a profitable production.

The Mexican race prospers in altitudes from 500 to 3,000 m; the Guatemalan of 1,000 to 2,000 m and the Antillean of 0 to 1,000 m.

Thermal requirements. Whiley and Winston (1987) point out that the avocado cv. Hass, for fruit mooring requires temperatures in a range that goes from 12-17 °C to 28-33 °C. Gafni (1984) it points out that higher temperatures than 42 °C are unfavorable for the cultivation. Lovatt (1990) indicated that the biggest mooring of avocado fruits happened with temperatures between 20 and 25 °C, on the other hand he pointed out that temperatures above 28 °C cause the abscisión of individual flowers.. Martínez (1988) and Benacchiopoint out as thermal thresholds of the avocado 10 and 35 °C. Hills (1988) and Jasso (1989) mentions that in the cultivation of the avocado higher temperatures than 32 °C have negative effects due to a detriment on the fertilization and the grade of sterility of the pollen. Yamada et al (1985) referred that the perspiration and the hydrological potential in the leaves of citric and avocado species was reduced when the temperature in the roots was low. The hydrological potential in the leaves was specially affected when the temperature of the air went down 5 °C.

It walls et to the one. (2006) it points out that in phenological studies carried out in the cultivation of the avocado in Michoacán in the climate type C(w2)(w), the requirements of units heat were determined (UC) taking as temperatures base 10 and 30 °C in the different phenological phases of the cultivation. Among other phases it was determined that in the normal flowering (December-January) 270 UC is required and in the formation of the fruit (January-October) 1800 UC.

Hydrological requirements.. In reference to the hydrological aspect in the avocado producing area of Michoacán, the water is a scarce natural resource, thus it must be saved from the abundant precipitations of June to October.

The physical properties of the volcanic soils where the avocado is cultivated, confer it hydraulic properties from 50 to 20 mm h<sup>-1</sup> of hydraulic conductivity, this property at the same time protects the radical system from illnesses from the root when evicting the big surpluses of water of June to October, it also favors the quick drying of the floor and the loss of nutriments and bases outside of the surface radical, and possible effects in the aquifers which can arrive to 1.0 m of depth in some avocado producing regions.

With these antecedents, it is understood the importance of the water handling has in the cultivation of the avocado of Michoacán, its readiness in certain regions, can mean the difference between obtaining 6 fruit ton/ha and the ascent to 12 ton/ha or even more. Walls et al. (2006), in investigation works carried out in the area producer of Michoacán, determined that the requirement of water of the avocado in the period of low water availability (December to May) varies according to the location of the plantations as for climate and altitude, being determined that the orchards located in climate (A)C(w2)(w). and in an altitude of 1,600 to 1,800 m require a sheet 458.8 mm, while plantations in climate C(w2)(w) and in altitudes of 1,900 to 2,300 m require 389.4 mm, and those that are in climate (A)C(w1)(w) to heights of 1,200 to 1,600 m abovd the level of the sea

need 530.1 mm. Alcántar and Aerie (1997) point out that in Michoacán, the avocado plantations that are on soils with franc-sandy textures or clay-sandy crumb (Figure 5), they require in the period from the third week of December to the first of June a sheet of water 491 mm, this quantity is very similar to the one suggested by Wall et al. (2006) who indicated a sheet of 437 mm for the same period. During the season of rains the values that register (1,600 mm) they satisfy the requirements of the cultivation completely.

Rodríguez (1982) mentioned by Larios et al. (1995) indicated that the environmental humidity influences in the quality of the fruit and in the sanity of the air part of the tree. High humidity conditions induce to the proliferation of the illnesses of the leaves, shafts and fruits. A good environmental humidity is that that doesn't overcome 60%.

Soil requirements. As for soil requirements Gardiazabal (2004) mentions that the upper layer of the earth where the plants grow is very complex, because of the great variability of their physical and chemical components that possesses. The avocado requires a very good drainage in the soil to be able to live and to take place, since it is one from the most sensitive species to the radical asphyxia. He also refers that the avocado doesn't need a very deep soils since it possesses superficial roots, producing abundant crops in floors from 30 to 40 cm deep, provided it has an underground an excellent drainage, or that it is located on hillsides. Nevertheless, a deep soil and of textures stockings, they are decisive conditions in the quantity of water that it can retain.

### GENERAL OBJECTIVE.

To provide technical information to level and Municipality of the agro-environmental variable, as fundamental tool for planning and decision taking related to the handling of the units of avocado production Hass in Michoacán.

### MATERIALS AND METHODS.

For the characterization of the avocado producing area, it left a climatic database and system of information referred to soil and clima generated in INIFAP for the state of Michoacán (Anguiano et to the one. 2003). The climatic database is compiled in the system SICA 2.5 (Medina and Ruiz, 2004) and he/she understands daily information of maximum and minimum temperature, rain and evaporation, corresponding to the period of the years 1961 at 2000, fed by 160 climatological stations settled down in Michoacán and 45 stations of adjacent states as Michoacán, all corresponding to the Net of Meteorological Monitoring of the National Commission of the Water (CNA) (Anguiano, 2005). Information was also included generated by means of the Program of Rising and Verification of Producers, Properties and Lots of the Cultivation of the Avocado in the State of Michoacán, coordinated by the National Council of Producing of Avocado (CONAPA) and the Commission Michoacana of the Avocado (he/she EATS) in the period 2003-2005, with support of the State Committee and Local Meetings of Vegetable Sanity, the Association of Producers and Packers Exporters of

Avocado of Michoacán (APEAM); Foundation Michoacán Takes place B.C., SAGARPA through ASERCA and the Secretary of Agricultural Development of Michoacán.

The area under study conformed it the following municipalities of the state of Michoacán: Acuitzio, Apatzingán, Ario de Rosales, Cotija, Los Reyes, Tingambato, New Parangaricutiro, Peribán, Salvador Escalante, Tacámbaro, Tancítaro, Tangancícuaro, Tangamandapio, Taretan, Tingambato, Tingüindín, Tocumbo, Turicato, Tuxpan, Uruapan, Ziracuaretiro and Zitácuaro.

The variables that were included to carry out the characterization were: Description of the municipality (geographical localization, territorial extension, surface planted with avocado, regime of property of the earth and surface of the orchards), climate type (García, 1988), altitude (INEGI, 2001), thermal régime (maximum temperature, minimum temperature, half temperature, accumulation of units heat and period free of icy), régime of humidity (rain, evaporation, requirements seasonal hídricos and relative humidity), characteristic edáficas (soil types - FAO, 1975 -, slope and change of soil use-FAO, 1999).

The variables of climatic type were characterized with base in annual values (Medina et al., 1998).

To determine the changes of soil use, they overcame the images of soil use (INEGI, 2001) and the image of the avocado producing fringe (COMA-CONAPA, 2005). For the stratification and generation of thematic maps, the programs IDRISI 32 were used (Eastman, 1999) and ARCVIEW GIS 3.2 (ESRI, 1999). To carry out the characterization by municipality, it was considered the range of values present in each one of them, intervals were determined with what the stratified surface was obtained. For example for the variable altitude, if in some municipality the range in which the avocado plantations are distributed was from 1,600 to 2,400 meters on the level of the sea, then it was determined to stratify it in ranges of 200 m of altitude, settling down for it four strata, 1,600 at 1,800, 1,801 at 2,000, 2,001 at 2,200 and 2,201 to 2,400 msnm. This way the percentage of the surface was determined with avocado that is in each one of these intervals. In a same way you proceeded with the rest of the variables considered in the study.

## RESULTS AND DISCUSSION.

According to the results of the Program of Rising and Verification of Producers, Properties and Lots of the Cultivation of the Avocado in Michoacán made in the period of the 2003-2005, the surface is of 78,050.31 hectares equal to 84% of the national avocado planted area; although still lack to incorporate to these data of the census more surface (7,000 ha approximately).

They exist 27 States that produce avocado in Mexico, in Michoacán there are 25 municipalities with plantations, of which three have up to 50 hectares, these they are: Tangancícuaro, Hidalgo and Chilchota; of 51 Acuitzio are to 750 hectares,

Cotija, Apatzingán, Taretan, Timber, Tuxpan and Tocumbo; less than 751 to 1,450 hectares, Ziracuaretiro is, Zitácuaro, Turicato and Tangamandapio; of 2,000 at 6,000 has, they are Salvador Escalante, New Parangaricutiro, Tingüindín and Tingambato; and the municipalities with more area are Tancitaro, Uruapan, Tacámbaro, Aryan and Peribán, with surfaces of 7,000 to more than 18,000 hectares.

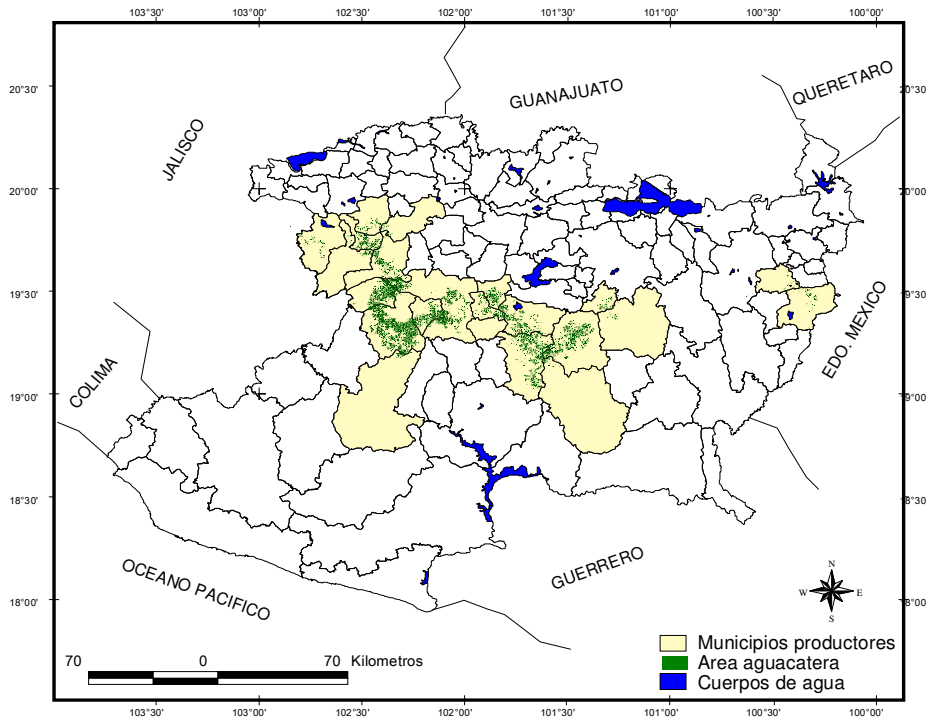


Figure 1. Municipalities producing of avocado of the state of Michoacán, Mexico.

In relationship to the regime of property, in Michoacán 69.7% of the orchards is small property, 25.1% is in terrestrial ejidales and 5.24% they belong to communal properties. As for the size of the properties, it varies from less than 5 until more than 30 there is; the biggest proportion corresponds to vegetable gardens whose surface is of less than 5 and of 5 to 10 hectares, because these they occupy the 37.2 and 20.2% respectively.

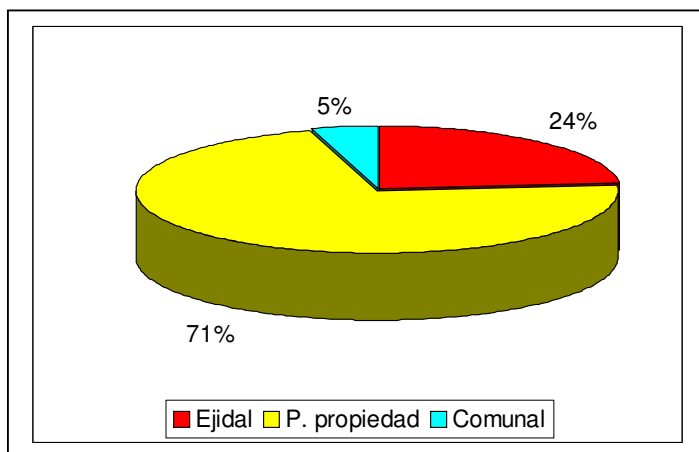


Figure 2. Distribution of the area avocado producer for régime of property

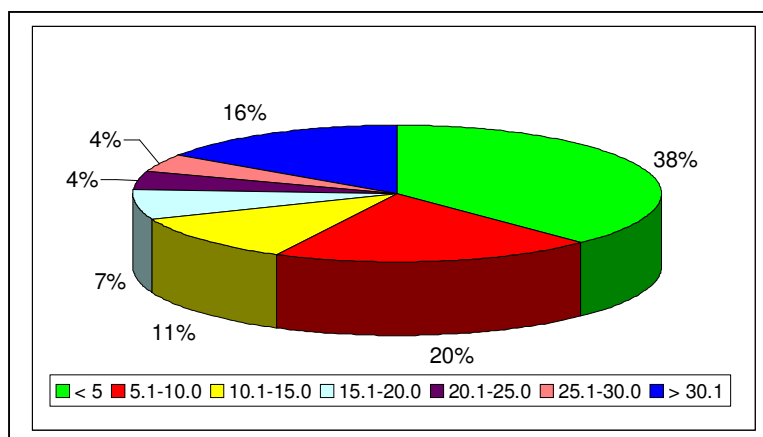


Figura 3. Distribución de la zona productora de aguacate por tamaño de propiedades

The conditions prevalent agroambientales in the region producer of avocado of Michoacán, propitiate a favorable development of the tree and the fruit obtaining practically the whole year. Three climatic types that are highlight: (A)C(w2)(w). Semicálido subhúmedo with rains in summer. % of winter rain smaller than 5. The most humid. In an altitude of 1,600 to 1,800 meters above the sea level . (A)C(w1)(w). Semicálido intermediate subhúmedo in humidity. All with rains in summer. % of winter rain smaller than 5. In an altitude of 1,200 to 1600 msnm. C(w2)(w). Tempered subhúmedo with rains in summer. % of winter rain smaller than 5. The most humid. In an altitude of 1,900 to 2,300 meters above the sea level..

With the purpose of characterizing the distribution of the avocado producing surface reported in the census by their environmental conditions, and with base to the analysis of the variable soil-climate described in this study, in the obtained following square of bibliographical references and field observations, each variable is specified with the appropriate ranges for the good and marginal conditions of the cultivation. This analysis is an indicator of the great advance that he/she has had the avocado in Michoacán in the change of use of the floor and that at the moment squatter important areas of forest vocation, and that given the great commercial peak that has had in the last years, is continued still planting without any control in non capable circumstances for the fruit-bearing one.

Regarding the variable altitude, in Michoacán 77% of the avocado producing area surface is distributed in good conditions and 23% in marginal.

As for the maximum temperature, 76% is in the good thing and 24% is marginal. For the minimum temperature, the percentages are respectively of 60% and 40%.

With relationship a period free of icy, 17% of the surface corresponds to the smallest danger, because in this alone stratum they exist 5 days in the year that you could present this catastrophe. In 9% of the surface, corresponding to the stratum less than 260 days, it is where the watering is more latent, because in the year 115 days in it could happen that frosts occur..

Table 1. Good and marginal requirements for the development of the avocado

Variable	Marginal mínimo	Óptimas	Marginal máxima
Altitud (msnm)	<1200	1,600 a 2,200	2,200 a 2,400
Temperatura (°C)	4 a 10	20 a 25	28 a 31
Periodo libre de heladas (No. de días)		Más de 360	
Lluvia (mm)		600 más riego	
Evaporación (mm)	650	1,168	1,000
Humedad relativa (%)	50	57 a 63	
Tipo de suelo		Andosol y Luvisol	
Pendiente (%)	2		15

In relationship to the accumulation of heat units, the cultivation requires 2,200 annual UC and in 24% of the surface accumulations are had smaller than 2,000 UC, what means that in those areas the avocado plant scarcely covers the energy contribution required to complete its phenological phases in 76% of its needs are satisfied optimally.

In what refers to precipitation and evaporation, during the season of rains and according to what demands the avocado plant, the quantities that register in the whole producing area satisfy 100% of their requirements, provided the pattern of rains is uniform during the annual cycle, however the evaporation and transpiration demands during the period of low water availability should be covered with watering water according to the necessities that are had in each atmosphere, because otherwise they will rebound directly about the production and quality of the fruit.

As for the relative humidity and according to the established approaches for this variable, one has that in 100% of the avocado producing fringe, good conditions exist for the cultivation.

With respect to the soil types where are the plantations, it was defined that 86% is in the type Andosol that is the good one for the cultivation, 5% in Luvisol, also with capable properties for the cultivation; 9% is distributed in other six types with suboptimal characteristics for the avocado tree.



In what concerns to the slope of the soil, 88% of the orchards is under good conditions, this is in slopes steep less than 15%, while 12% is under marginal conditions, since when being in superior slopes to 15%, it implies non appropriate conditions for the handling of the cultivation, like it is the plant health control, practical cultural, I water and it harvests, nevertheless this condition is favorable in areas with high risk of frosts.

Table 2. Situation of the surface aguacatera of Michoacán for good and marginal conditions for the development of the avocado

Variable	Óptima %	Marginal %
Altitud	77	23
Temperatura máxima	76	24
Temperatura mínima	60	40
Lluvia	100	
Humedad relativa	100	
Tipo de suelo	86	14
Pendiente	88	12
Periodo libre de heladas	9 % en condiciones de máximo riesgo	

The analysis of the information was carried out of the image of use of the soil connected with the one that was obtained of the avocado producing fringe through the census, indicates that 20% of the surface that at the moment is covered by the cultivation of the avocado, until the year 2000 were occupied by forest species, this figure captures the growth that has had the avocado producing fringe in detriment of the natural resources of the region.

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