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Agro-Climatic factors required for the correct development of pineapple (*Ananas comosus* (L.) Merr.) cultivation

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ABSTRACT

Objective: To compare the agro-climatic factors: soil, rainfall, sunshine duration (sun-hours) and temperature existing in the municipality of Tecomán, Colima, Mexico, to some optimum values, in order to determine the development of the MD2 pineapple (*Ananas comosus* (L.) Merr.) plantation crop.

Design/Methodology/Approach: For the soil factors, texture and pH, data were obtained in laboratory to determine soil physical and reaction analyses. For temperature and rainfall, data were obtained from the Sistema Meteorológico Nacional (SMN), and to obtain the optimal values, different authors cited in the bibliography were considered.

Results: the soil factor presented a sandy loam texture with a pH of 7.9. From January to June and from October to December, a monthly precipitation deficit (mm) in percentage was evidenced respect that required by pineapple cultivation; and a percentage of excess in monthly precipitation (mm), from July to September. For monthly sunshine duration, an excess between 200 and 300% of sun-hours was evidenced with respect to that required by pineapple. For minimum, maximum and average temperature, monthly variations were evidenced, but within acceptable ranges according to those determined for cultivation development.

Limitations of the study/Implications: No scientific information was available regarding pineapple cultivation evaluated at the research area.

Findings/Conclusions: It was determined that the evaluated pineapple plantation crop will be able to develop in the production area, by adjusting monthly precipitation deficit through an irrigation system and the excess of sunshine duration, through the use of a shade cloth.

Keywords: Alternatives, tropical crops, agro-climatic factors.

INTRODUCTION

Pineapple (*Ananas comosus* (L.) Merr.) is native to tropical areas of South America, such as Brazil and Paraguay. It is not known in a truly wild state and it does not seem to be derived from the other species of edible fruits of the genus *Ananas* (L.) Merr., (Bromeliaceae), such as *A. bracteatus*, *A. fritzmuelleri*, *Actifolia* and *A. ananasioides*, which produce very small fruits with few seeds (Avelino *et al*., 2009). In addition, according to Cerrato (2013a), the market of this fruit has increased due to consumer demand for healthy foods. As it is the tropical fruit with the highest demand in the world due to its pleasant taste and higher contents of fiber; C, B1, B6 vitamins; folic acid; and minerals like potassium.

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In Mexico, pineapple cultivation of the MD2 variety, also known as Super Sweet pineapple, is produced under irrigated or rain-fed (the water required for the crop is provided by rains) conditions, but the rain-fed system is predominant. From 2001 to 2008, more than 98% of the area planted with pineapple was under this condition. According to the Servicio de Información Agroalimentaria y Pesquera (SIAP, 2017), in 2016 those five states with the highest volume of Mexican pineapple production were Veracruz (65%); Oaxaca (13%); Tabasco (6%); Quintana Roo (5%) and Jalisco (4%) that jointly contributed 93% of the total national production. For the proper development of pineapple cultivation, it is necessary to have suitable values of several agro-climatic factors. In this research, emphasis is placed on the type of soil (texture and pH), rainfall, sunshine duration, and temperature. The aim of this study was based on identifying if pineapple cultivation would achieve adapting to those agro-climatic conditions present in the study area. And on implementing those agricultural management or techniques to accomplish proper plantation crop development. Based on the above, agro-climatic factors: soil, rainfall, sunshine duration, and temperature existing in Tecomán, Colima, Mexico, were evaluated to compare them with some cited optimum values of those same factors to determine the adequate development of the MD2 pineapple plantation crop.

MATERIALS AND METHODS

The research was carried out at La Parota site (18° 54.12 N, and 103° 50.21 W) (Google Earth, 2017), during 2017 and 2018. According to the Instituto Nacional para el Federalismo y el Desarrollo Municipal (INAFED, 2017), the specific conditions of the area include an altitude of 33 m above average sea level; an average temperature of 26 °C and annual rainfall of 484.9 mm. An identification of the soil, texture and pH, was determined through physical analyses carried out on the soil samples obtained in the study area and processed in a certified laboratory (Agrolab) in the state of Colima. The analyses consisted of determining the texture and reaction of the soil, and to establish the pH value of the soil (Water 1: 2; $CaCl_2$ 1: 2). Regarding agro-climatic factors, for rainfall and temperature, data were obtained from the Sistema Meteorológico Nacional (SMN) for the period 1963 - 2017. The optimal data of the agro-climatic parameters studied were obtained from different authors and organizations with specific information for pineapple cultivation, such as Doorenbos and Kassam (1979), Bartholomew *et al*. (1985), FAO (1994), Sánchez and Caraveo (1996), Castellanos *et al*., (2000), Sandoval and Torres (2011) and others indicated in the bibliography. The scatter plots of the different factors evaluated were done by using Infostad® and numerical tables were processed on Microsoft Excel™ 2016.

RESULTS AND DISCUSSION

Soil physical analysis determining soil texture, recorded 51% sand, 15% clay and 34% silt, thus classifying the soil as sandy loam (USDA, 1993). With this result, it can be indicated that the area under study presents an adequate soil texture for the development of pineapple plantation crop; as compared with that indicated by Bartholomew *et al*. (1985), who mentioned that the pineapple cultivation requires soils with medium texture, sandy loam, or clay loam. In addition, Dávila (2016), also indicates that pineapple cultivation requires soils with a sandy texture, sandy loam or clay sand. Results of the soil reaction analysis and pH determination of the samples indicated that the soil has a pH (Water 1: 2) value of 7.9 which is considered mildly alkaline, and the result of the reactive pH ($CaCl_2$ 1: 2) showed a value of 7.26 that is cataloged as Neutral. When comparing these results with the optimal ranges established by FAO (1994), it is possible to note that pH can be limiting, because although the plantation crop can develop in soils with pH values 3.5 to 8.0, the optimum value is 5.9. In addition, comparing this result with that indicated by Doorenbos and Kassam (1979) we note that neither is in the range considered as optimum by these authors, which is between 4.5 to 6.5. Whereas Castellanos *et al*. (2000) set it between 5.0 - 6.0, and Dávila (2016) between 4.5 and 5.5. Thus, with a pH from neutral to mildly alkaline, the plantation crop would have to develop exposed to a range outside the optimum mentioned above and, in this particular case, higher than that recommended. As indicated by Acosta (2006), the solubility of nutrients could be decreased, specifically iron, phosphorus, manganese, zinc and copper, which, if not considered during the establishment of the plantation crop, can lead it to nutrition and development problems. Table 1 shows that there is a deficit percentage of monthly precipitation (mm) at Tecomán, regarding the monthly average required for pineapple cultivation in the months of January (−78.44%),

February (−94.75%), March (−93.58%), April (−99.55%), May (−84.29%), June (−8.24%), October (−27.07%), November (−83, 71%) and December (−89.19%). In addition, it is possible to determine that there is an excess percentage in monthly precipitation (mm), respect that required, in the months of July (20.05%), August (36.77%) and September (53.94%).

This behavior of monthly rainfall deficit and excess at Tecomán (Figure 1), especially in the months January - June and October-December, need to be supplied / controlled by irrigation, as indicated by Dominguez (1985).

Table 2 and Figure 2 show a percentage of excess in monthly sun-hours at Tecomán respect the monthly sun-hours required for pineapple cultivation in every month. This excess accounts for: January (245.34%), February (217.10%), March (273.09%), April (270.65%), May (297.27%), June (300.08%), July (298.97%), August (285.64%), September (276.35%) October (254.02%), November (241.40%) and December (247.20%). Thus, exceeding the 100 sun-hours indicated by Sandoval and Torres (2011).

By noticing the above and acknowledging that there is a high sunshine duration at Tecoman, it is considered

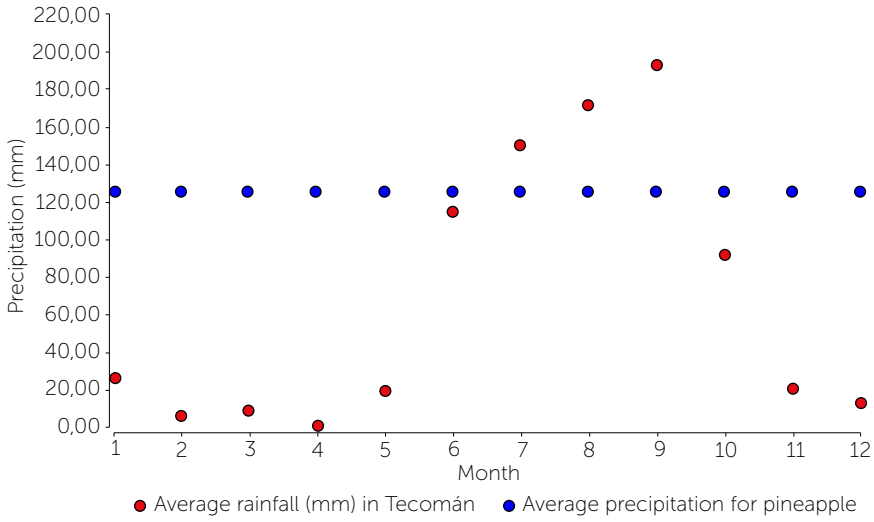

Figure 1. Monthly precipitation (mm) of Tecomán versus the ideal for pineapple cultivation. Source: (Own elaboration, 2018 according to the data of the National Meteorological System SMN).

Table 1. Description of monthly precipitation data (mm) for Tecomán versus the ideal for pineapple cultivation.

Concept	January	February	March	April	May	June	July	August	September	October	November	December
Years with data.	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00
Minimum monthly precipitation (mm) of Tecomán.	0.00	0.00	0.00	0.00	0.00	2.10	21.70	38.00	1.20	0.00	0.00	0.00
Maximum monthly precipitation (mm) of Tecomán.	498.90	115.80	160.50	19.00	212.90	445.30	517.20	405.70	648.50	421.50	316.00	97.20
Average monthly precipitation (mm) of Tecomán.	26.95	6.56	8.03	0.44	19.64	114.70	150.06	170.96	192.42	91.16	20.36	13.51
Standard deviation.	77.68	21.08	30.82	2.62	45.62	85.48	101.01	95.14	136.08	94.87	52.04	25.42
Average monthly precipitation (mm) required by pineapple cultivation.	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00	125.00
Difference of mean monthly precipitation (mm) of Tecomán versus required by pineapple cultivation.	-98.05	-118.44	-116.97	-124.56	-105.36	-10.30	25.06	45.96	67.42	-33.84	-104.64	-111.49
% Variation.	-78.44%	-94.75%	-93.58%	-99.65%	-84.29%	-8.24%	20.05%	36.77%	53.94%	-27.07%	-83.71%	-89.19%

Source: Own elaboration, 2018 according to the data of the National Meteorological System SMN.

Table 2. Description of the data of Hours of monthly light of Tecomán versus the ideal one for pineapple cultivation.

Concept	January	February	March	April	May	June	July	August	September	October	November	December
Hours of monthly light in Tecomán.	345.34	317.10	373.09	370.65	397.27	400.80	398.97	385.64	376.35	354.02	341.40	347.20
Hours of monthly light required by growing pineapple.	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Difference of monthly light hours of Tecomán versus monthly light hours required by the pineapple crop.	245.34	217.10	273.09	270.65	297.27	300.80	298.97	285.64	276.35	254.02	241.40	247.20
% Variation.	2.45	2.17	2.73	2.71	2.97	3.01	2.99	2.86	2.76	2.54	2.41	2.47

Source: Own elaboration, 2018 according to data from Weatherspark.

important to protect the fruit, by using shade cloth to avoid affecting the quality of the product, due to sunburn problems to the shell. According to Cerrato (2013b), this shading method has resulted effective for pineapple producers.

Table 3 and Figure 3 show deficit in monthly maximum temperature (°C) at Tecomán concerning the maximum monthly temperature tolerated by pineapple cultivation in every month (January −6.69%, February −6.91 %, March −6.74%, April −5.97%, May −3.83%, June −2.43%, July −1.86%, August −2.14%, September −3.49%, October −2.03%, November −2.66%, and −5.09% in December).

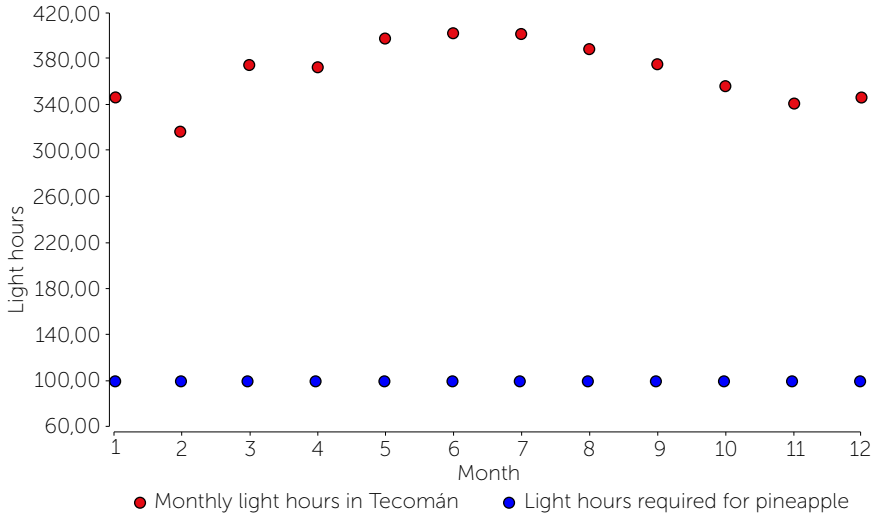

Figure 2. Hours of monthly natural light in Tecomán versus the ideal for pineapple cultivation. (Own elaboration, 2018).

The behavior of deficit in the monthly maximum temperature (°C) at Tecomán with respect to the maximum temperature (°C) tolerated by pineapple cultivation, can be observed in Figure 4, where the maximum monthly temperatures are in every month below the maximum that the pineapple plantation crop could resist, which is why the crop would adjust well to this parameter.

Minimum temperature

Table 4 and Figure 4 provide evidence of a deficit percentage in minimum temperature (°C) at Tecomán, regarding the minimum temperature suitable for pineapple cultivation in the months of January (−16.85%), February (−18.75%), March (−17.75%), April (−12.05%) and December (−10.20%). Also, it was determined an excess percentage in the monthly temperature at Tecomán, in relation to that required, in the months of May (0.65%), June (15.40%), July (16.40%), August (15.50%), September (14.65%), October (12.15%) and November (0.90%).

According to Pinto (2012) and Sanchez and Caraveo (1996), low temperatures retard growth and development, and can set floral differentiation in advance.

Average temperature

Regarding the adequate average temperature of 25-27 °C for pineapple cultivation, it was observed through

Table 3. Description of monthly maximum temperature (° C) data for Tecomán versus the monthly maximum temperature (°C) supported by pineapple cultivation.

Concept	January	February	March	April	May	June	July	August	September	October	November	December
Years with data.	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00
Minimum monthly maximum temperature (°C) of Tecomán.	29.69	30.24	29.69	28.70	30.37	31.63	31.18	31.95	31.55	32.32	31.90	30.84
Maximum monthly maximum temperature (°C) of Tecomán.	35.73	35.59	35.89	35.62	37.10	36.85	37.06	37.81	36.98	38.65	37.55	36.58
Average monthly maximum temperature (°C) of Tecomán.	32.59	32.59	32.64	32.91	33.66	34.15	34.35	34.25	33.78	34.29	34.07	33.22
Standard deviation.	32.59	32.59	32.64	32.91	33.66	34.15	34.35	34.25	33.78	34.29	34.07	33.22
Average monthly maximum temperature (°C) supported by pineapple cultivation.	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Difference of mean maximum temperature (°C) of Tecomán versus supported by the pineapple crop.	-2.41	-2.42	-2.36	-2.09	-1.34	-0.85	-0.65	-0.75	-1.22	-0.71	-0.93	-1.78
% Variation.	-6.89%	-6.91%	-6.74%	-5.97%	-3.83%	-2.43%	-1.86%	-2.14%	-3.49%	-2.03%	-2.66%	-5.09%

Source: Own elaboration, 2018 according to the data of the National Meteorological System SMN.

analysis, monthly deficit in the months of January (−1.56%), February (−2.32%) and March (−1.72%). Also, it was determined an excess percentage in monthly average temperature (°C) at Tecomán, regarding that required, in the months of April (1.00%) May (7.60%), June (14.44%), July (15.28%), August (14.68%), September (13.40%), October (13.44%), November (8.48%) and December (2.36%).

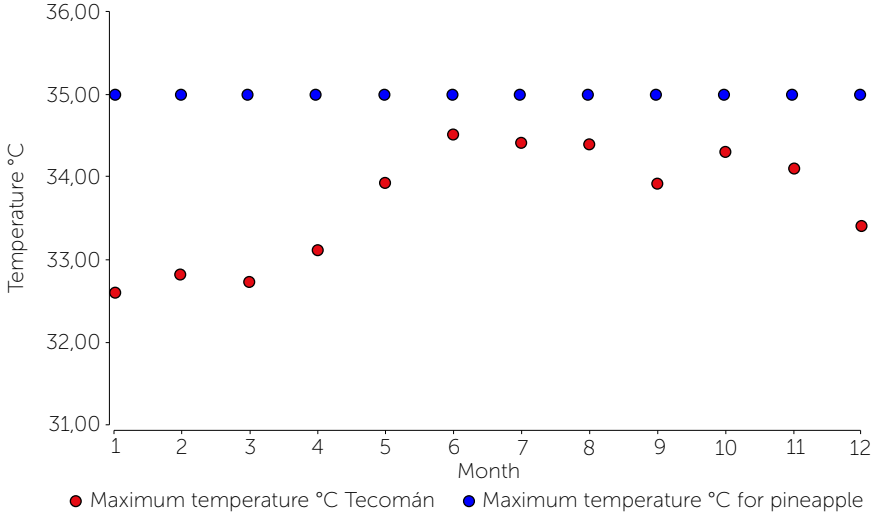

Figure 3. Maximum monthly temperature (°C) of Tecomán versus the ideal monthly maximum temperature (°C) for pineapple cultivation. Source: (Own elaboration, 2018, according to data from the National Meteorological System SMN).

CONCLUSIONS

Regarding the parameters of soil texture and temperatures (minimum, maximum and average), the pineapple plantation crop can adapt. However, soil pH showed neutral to mildly alkaline values, outside the optimal range, which could cause a decrease in the solubility of nutrients, specifically iron, phosphorus, manganese, zinc and copper. On the rainfall factor, it was determined that the amount of annual precipitation does not cover the requirements for pineapple plantation during eight months of the year, thus, recommendation is to implement an irrigation system to supply the water needs in those months with deficit. In addition, on the subject of sun-hours, the site study presented values almost three

Table 4. Description of monthly minimum temperature (°C) data for Tecomán versus the ideal minimum temperature (°C) for pineapple cultivation.

Concept	January	February	March	April	May	June	July	August	September	October	November	December
Years with data.	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00	54.00
Minimum monthly minimum temperature (°C) of Tecomán.	12.13	12.00	12.40	12.07	16.35	16.67	21.35	20.81	20.20	20.16	16.30	14.37
Maximum monthly minimum temperature (°C) of Tecomán.	20.34	19.86	19.77	21.42	24.69	25.47	24.76	24.60	24.32	24.92	22.70	21.13
Monthly minimum temperature (°C) of Tecomán.	16.63	16.25	16.49	17.59	20.13	23.08	23.28	23.10	22.93	22.43	20.18	17.97
Standard deviation.	1.67	1.80	1.53	1.93	1.60	1.27	0.68	0.76	0.71	0.92	1.17	1.47
Minimum monthly temperature (°C) required for pineapple cultivation.	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Minimum temperature difference (°C) of Tecomán versus required by pineapple cultivation.	-3.37	-3.75	-3.51	-2.41	0.13	3.08	3.28	3.10	2.93	2.43	0.18	-2.04
% Variation	-16.85%	-18.75%	-17.55%	-12.05%	0.65%	15.40%	16.40%	15.50%	14.65%	12.15%	0.90%	-10.20%

Source: Own elaboration, 2018 according to the data of the National Meteorological System SMN.

times those required by the pineapple plantation crop, which can affect the quality of the fruit, as it is exposed to damage during flowering and development stage due to sunburn. MD2 pineapple cultivation would reach full development, as long as some adjustments on the limiting factors, rainfall (deficit) and sun-hours (excess) are made in order to achieve good-quality commercial productions.

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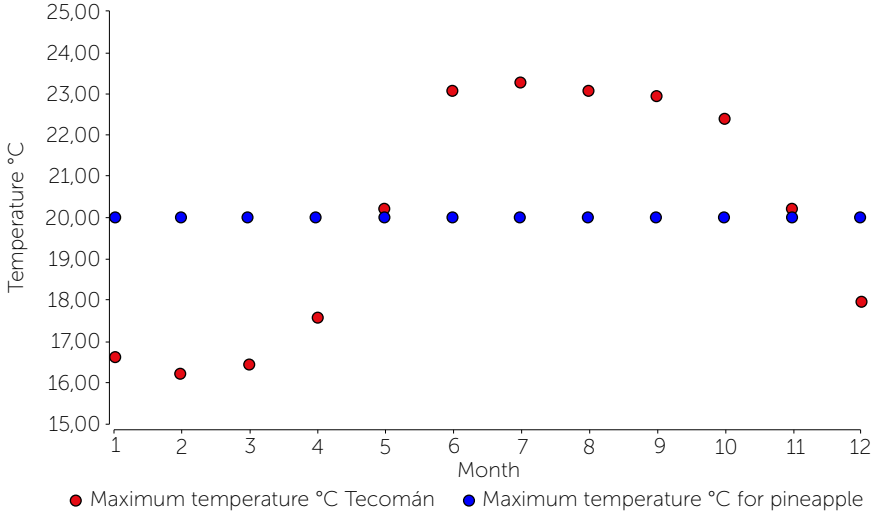

Figure 4. Monthly minimum temperature (°C) of Tecomán versus the ideal monthly minimum temperature (°C) for pineapple cultivation. Source: (Own elaboration, 2018, according to data from the National Meteorological System SMN).

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