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# Weather Variability and Its Contributions to Produce in The Municipality of Lagoa Seca, Paraíba – Brazil

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**ABSTRACT**

The objective is to show the behavior of meteorological elements in the municipality of Lagoa Seca, aiming at a contribution to sustainable development in the productive areas of vegetables, legumes, and fruit. The meteorological elements studied were: maximum temperature, minimum temperature, average air temperature, thermal amplitude, relative humidity, wind (intensity and direction), insolation, cloud cover, evaporation, evapotranspiration, precipitation, days with occurrences of rain, photoperiod. The rainfall data worked corresponded to the 1981-2012 series, provided by the Executive Agency for Water Management of the State of Paraíba. The average temperature ranged from 19.4°C to 23.1°C, the maximum temperature ranged from 23.4 °C to 28.7 °C and the minimum between 16.2°C to 19.9°C. The range of thermal amplitude is from 6.3°C to 10.2°C. The average relative humidity of the air is 72% to 87%, the average annual precipitation is 1,097.3 mm, it was observed that the annual march of the relative humidity of the air follows the annual distribution of precipitation, because precipitation is the process supply from natural sources of water vapor and moisture. The total insolation ranged from 165.9 to 258.1 hours and its annual average is 2, 557.4 hours. Annual evaporation is 1,420.9 mm and annual evapotranspiration is 1,776.1 mm, annual wind speed is 3.01 ms-1, with an annual cloud cover of 0.6 tenths. The computation of the water balance for CAD's 25, 50, 75, 100, 125, and 150 mm aiming at reducing energy and water consumption, reducing the time of use of the water pump used in irrigation.

## INTRODUCTION

The reduction of natural vegetation cover and the fragmentation of forest ecosystems is a worldwide phenomenon, affecting almost all biomes. In the case of the caatinga, this fragmentation is serious, it is an important factor for biological impoverishment. In addition to its serious consequences for biodiversity, it also compromises a series of functions of forest ecosystems, including the conservation of water resources (VIANA, 1998).

Urban agriculture is an activity carried out in backyards, vacant lots, gardens, or balconies that aim to produce vegetables, medicinal and ornamental plants for their consumption or sale, or it may have another focus such as educational, recreational, and social activities or even to wake up interest and encourage a healthier eating habit, especially in children (FILGUEIRA, 2007; SEABRA et al., 2003; CRIBB et al., 2009).

The sustainable management of the environment involves planning their use, which needs to assess natural resources and determine their conditions of spatial occupation, using concepts introduced in the assessment of environmental problems and taking into account their environmental characteristics such as climate, vegetation, soils, lithology, geomorphology and land use and occupation.

Current discussions on the limitation of freshwater reserves on the planet, linked to concerns about a possible future scarcity of this resource, necessarily lead to a reflection on the number of water resources available in groundwater, rivers, hydrographic basins, dams, lakes, ponds, streams and streams. The issues related to water quality are also highlighted, compromised on a local scale, mainly by human activities that raise doubts about the effective availability of water resources in quality (Sperling, 2006). It is noteworthy that a good part of urban or semi-urban water, in general, is contaminated by domestic sewage and in some rural areas by the inappropriate use of pesticides and animal diseases.

Related to these issues Tucci (2000) highlights the functionality of the hydrological cycle, which refers to a global phenomenon of water circulation. This cycle is linked to the interchange between the movements of water on the Earth's surface and the atmosphere, basically driven by solar energy associated with gravity and Earth's rotation. The hydrological cycle is usually studied with greater interest in the terrestrial phase, where the most used spatial cutout is the

open-air water tables, rivers, and hydrographic basin, as well as in the determination of irrigation intervals, in the prediction of agricultural productivity, in the classification climate, among other various activities, involving the management and planning of water resources.

Molion (1985) argues that to understand the formation of a region's climate it is necessary to consider some fundamental factors such as the general circulation of the atmosphere (the result of differential warming between the equator and the poles), the asymmetric distribution of continents and oceans and the hydrological cycle, especially concerning the distribution of rainfall, it is also one of the elements with the greatest influence on human activities.

Agrometeorological models and the interpretation of climate data related to crop growth, development, and productivity provide information that allows the agricultural sector to make important decisions, such: better land use planning, crop adaptation, monitoring and forecasting of crops, pest and disease control research and planning strategies (LAZINSKI, 1993).

Brazil is a very large country and the cultivation of vegetables in soil or hydroponics is economically viable in almost all climate basins in the country. From the northeast, in the semiarid climate, through the southeast with humid tropical and subtropical climate; Midwest, with a continental tropical climate, to the southern region with a subtropical and temperate climate, cultivation is possible as long as efficient technologies are used to control the microclimate.

Among the various economic activities in the municipality of Lagoa Seca, the cultivation of horticultural products (especially oranges, bananas and chayote) and poultry farming predominate.

In agriculture, raising cattle, pigs, and sheep strengthens the local economy. Manoel Pereira's flour industry is the main base of industrial activity in the city.

In trade, manioc flour, potatoes, chicken for slaughter, fruits, and vegetables are distributed throughout the micro-region (Figure 1). The fair held on weekends sells a wide range of products, serving as a commercial link between Lagoa Seca and neighboring cities.

The various interrelationships existing between the conditioning factors of the climate, when well analyzed and properly interpreted, allow to mitigate the impacts caused by the occurrence

of external and sporadic phenomena, on living organisms and agricultural, industrial, commercial, leisure, and sports activities of the area in question.

## MATERIALS AND METHODS

The map drawn up by the Rural Workers Union of Lagoa Seca was used, where it delimits regions of Roçados; river encounters; region of vegetables; hillside sites; fruit and agreste regions, Figure 1. The municipality of Lagoa Seca is located in the Microregion Lagoa Seca and the Mesoregion Agreste Paraibano in the State of Paraíba. Its territorial area is 109 km² representing 0.1937% of the State, 0.007% of the Northeast Region, and 0.0013% of the Brazilian territory. According to the EGBI (Brazilian Institute of Geography and Statistics), in 2006 its population was estimated at 26,000 inhabitants. The city is limited by the municipalities of Campina Grande, Massaranduba, Matinhas, São Sebastião de Lagoa de Roça, Montadas, Puxinanã and Esperança. The seat of the municipality is located at Latitude 07º10'15'' south; Longitude 35º51'13'' west of Greenwich with an approximate altitude of 634 meters at a distance of 109.4 km from the capital. Access is made, from João Pessoa, via the BR 230/BR 104 highways.


**Figure No.1. Maps of the regions of Lagoa Seca.**

**Source:** Lagoa Seca Rural Union

The southern part of the municipality of Lagoa Seca is located in the domains of the hydrographic basin of the Paraíba River, in the Lower Paraíba region, with the main watercourse being the Marinho stream. In the northern and eastern parts, they are located in the Mamanguape river basin, whose main watercourse is the river itself. All watercourses in the municipality have an intermittent flow regime and the drainage pattern is dendritic type.

For the development of this article, monthly and annual precipitation data series were used for the period of 31 years of observed data (1981-2012), provided by the Executive Agency for Water Management of the State of Paraíba (AESA, 2011). Temperature data were estimated (because there is no meteorological station) by the Estima_t software, (CAVALCANTI et al, 1994). The relative humidity data; predominant wind intensity and direction, total insolation, cloud cover, reference evaporation, evapotranspiration were estimated from the conventional meteorological stations of the National Institute of Meteorology (INMET, 2015) of the surrounding municipalities, covering the period from 1962 to 1991.

The Climatological Water Balance was carried out according to the methodology of Thornthwaite et al. (1955, 1948), with an estimate of the potential evapotranspiration, through the Normal Water Balance computer program, using an Excel spreadsheet developed and made available by Medeiros (2009).

The climate is classified as hot and humid Tropical rainy - class “As'”, according to Köppen (1931); Alvares et al., (2014).

Under higher thermal regimes, citrus plants emit several vegetative and floral outbreaks throughout the year, which makes possible the existence of different harvesting times. The various harvests obtained throughout the annual cycle result in the greater overall productivity of trees when compared to those that vegetate in places with milder temperatures.

Thermal amplitudes vary according to latitude, altitude, and degree of continentality (effects of mountains, valleys, hills, etc.).

## RESULT AND DISCUSSION

The study contains an analysis of the most relevant aspects of the climate for the municipality of Lagoa Seca, PB. Regression line calculations were performed for meteorological data referring to the following parameters: relative humidity, evapotranspiration, evaporation, cloudiness, total insolation, temperatures (maximum, minimum, average, thermal amplitude), wind direction, and speed, taking the base of the climatological database of neighboring municipalities that have meteorological information. The photoperiod (effective length of the day) was also estimated, making use of astronomical information. Finally, the second fluid balance was performed (THORNTHWAITE 1948; THORNTHWAITE et al. 1955).

Rainfall is a fundamental attribute in the analysis of tropical climates, reflecting the role of the main currents in atmospheric circulation. In the municipality of Lagoa Seca specifically, rainfall is fundamental for the good development of the regime of perennial rivers, streams, streams, levels of lakes and ponds, as well as for the occupation of the soil, is essential to the planning of any activity the knowledge of its dynamics.

Rainfall becomes the only source of water supply. Therefore, when draining on the surface, the water is blocked in small dams and used for supply. In addition, often a small fraction is captured and stored in cisterns for drinking purposes. However, this climatic element is extremely variable both in magnitude and in Spatio-temporal distribution for any region and, in particular, in the Northeast of Brazil (ALMEIDA et al., 2004; ALMEIDA et al., 2007).

The precipitation regime that comprises the municipality of Lagoa Seca, located in the northern part of the state of Paraíba, falls within the isohyet range (the line that unites the same precipitation value) from 1,100.0 to 1,200.0 mm/year.

In the municipality of Lagoa Seca, in general, the rain starts around the second half of March, increases in volume in the first days of April, and lasts until August, with the rainiest quarter from May to July.

The factors causing rainfall in the municipality are formations of instability lines on the coast and transported inland by the southeast/northeast trade winds, development of convective clusters, from the heat stored on the surface and transferred to the atmosphere, orography,

contributions from the formation of cyclonic vortices, and having as the main system the positioning of the Intertropical Convergence Zone (ITCZ).

Usually, the rains have moderate intensity (of regular weather and around eight to ten hours of daily discontinuous rain), followed by irregularity due to the failures of the active meteorological systems. It should be noted that the occurrence of dry spells (occurrences of several consecutive days without rain during the rainy season) in the wettest four-month period (April to July) is possible and varies from year to year. Its magnitude varies depending on the season and meteorological factors. Occurrences with periods of summer periods exceeding seventeen (17) monthly days have been registered in the time interval that occurred within the four months.

Figure 2 shows the graph of rainfall climatology, and days with occurrences of rain, for the municipality of Lagoa Seca.

The climatological precipitation curve shows us that during the year the pluviometric indexes are quite irregular. The months with the greatest amounts of rain are from March to August with fluctuations ranging from 110.3 to 181.2 mm/month; from September to December rainfall is insignificant for agriculture, storage, and impoundment of water in the soil and weirs with monthly total values ranging from 21.7 to 25.0 mm/month, the average annual interpolated rainfall is 1,118.0 mm/year.

The variability with which the annual rainfall totals follow each other portrays the climatic rhythm that is closely related to the mechanism of regional atmospheric circulation, due to spatial and temporal irregularities in the distribution of rainfall.

The understanding of the climatic rhythm is completed with the analysis of the pluvial regime, that is, of the monthly distribution of rains. Although the studied area has an irregular distribution of rainfall during the year, two periods stand out, defining a very marked zonal limit between dry and rainy and vice-versa.

Note: historical average, climatological average, and/or climatological normal is the arithmetic average value of any meteorological parameter, and for the designation of climatological normal the average value must be 30 years.

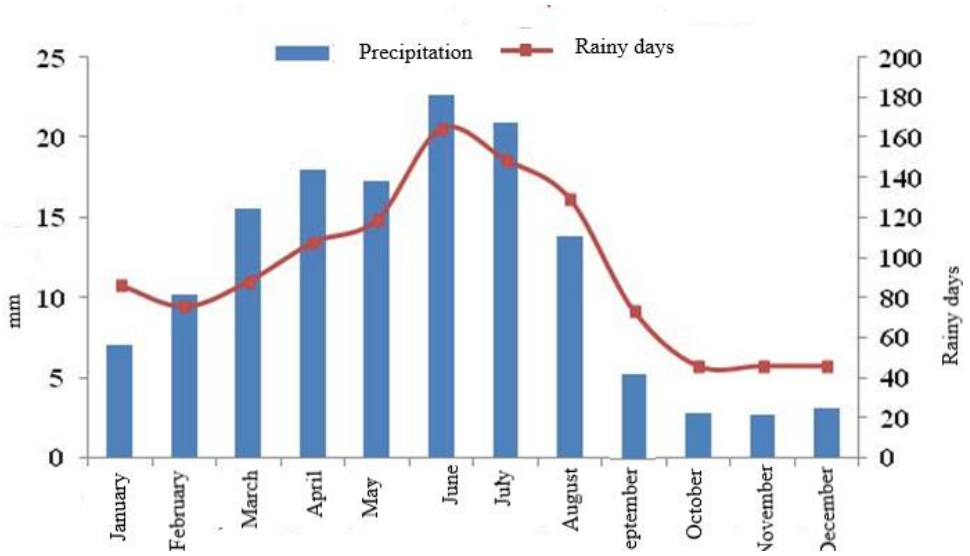


**Figure No. 2 shows the graph of rainfall climatology, and days with occurrences of rain, for the municipality of Lagoa Seca.**

**Source**: Agrometeorological study for the state of Paraíba. Medeiros (2016).

**Temperatures: maximum, average minimum, and thermal amplitude**

Despite its territorial extension, the state of Paraíba has a reduced number of meteorological stations that measure and/or record temperature data. To overcome this limitation, as well as the issue of time needed to obtain representative average values, the estimation of this climatic element has been used, as a function of geographic coordinates: latitude, longitude, and altitude. It was found that latitude and longitude have little significant influence compared to altitude.

The temperature presents an inverse variation with increasing altitude, as there is an adiabatic decompression as the air rises in the atmosphere, which causes it to cool. Larger intervals of temperature variations (maximum, minimum, and average) occur in a dry climate because of the greater solar irradiance and the large losses of long waves. Another important factor to be considered is that it moves away from the coast to the interior of the continent, the variations in daily, monthly and annual thermal amplitudes increase, a phenomenon that is called continentality, which is very characteristic of our state.

Temperature is one of the most important factors for agriculture, influencing agricultural growth, development, and production.

Several meteorological or even physical factors influence the temperature. They are the amount of insolation received by the land or part of it, cloud cover, the relative distance of water bodies, relief, the nature of the prevailing winds, ocean currents, and the positioning of each location on the surface of the globe.

Seasonal variations in temperatures are greatest in extratropical areas, particularly in continental interiors, while they are lowest around the equatorial band, particularly in the water surface. In the intertropical zone, the sun is at its zenith twice a year, on the way from one solstice to another.

The energy incident on the ground decreases as the sunset approaches until the value zero when it sets. The soil, in turn, having been heated by solar radiation, continuously loses energy and, consequently, cools down. Just before the sun rises, the soil has the lowest possible energy, that is, with the minimum temperature, which occurs at the same moment in the meteorological shelter.

The most favorable temperature, according to some surveys, for people engaged in active work, outside or inside the confined environment, is around 18.0°C, although there may be small individual differences. More work would be done, with less fatigue around that temperature.

Persistent heat and cold are depressing. The extreme temperature duration is significant. A hot summer day may be bearable, but with each successive hot day, work output decreases, vitality decreases, and the death toll increase among those whose bodies do not adapt quickly to the new weather conditions.

Extreme temperatures (maximum, minimum, average, and thermal amplitude) among the meteorological variables, are those that exert the greatest direct and significant effect on many physiological processes that occur in animals, plants, and soil, thus being important information for agriculture.

The variation in temperature in its spatial distribution depends on the latitude associated with the altitude, just it does to the seasons of the year, it depends on the evolution of nebulosity and the regular effect of continentality.

In the innermost part, where the regulating effect of continentality is significantly increased in the rainy season, the increase in cloudiness causes the registration of smaller numbers for the daily temperature range, which is now situated close to 8.4 ºC.

Figure 3. Shows the climatology graph of maximum, minimum, average, and thermal amplitude (ºC) for the municipality of Lagoa Seca.

The maximum temperature variability starts with a significant increase from the second half of August and continues until the beginning of the second half of May with monthly fluctuations flowing between 25.4ºC and 28.7ºC. The maximum annual temperature is 26.6ºC.

The minimum temperature is 18.3ºC, its maximum buoyancy occurs between September and June with fluctuations from 17.0ºC to 19.9ºC, the months of July and August are the months with the lowest occurrences of minimum temperature with oscillations of 16.3ºC and 162ºC, respectively.

Lagoa Seca has an average annual temperature of 21.5ºC and its monthly fluctuations occur between 19.4ºC (July, August) to 22.9ºC in March.

The annual temperature range in the municipality of Lagoa Seca is 8.4ºC and its monthly fluctuations range from 6.3ºC (June) to 10.2ºC (November).

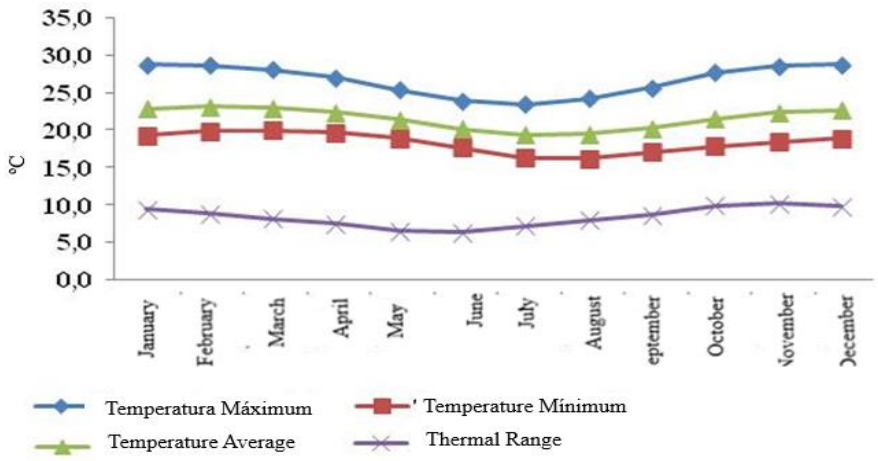


**Figure No. 3. Climatology graph of maximum, minimum, average, and thermal amplitude temperatures for the municipality of Lagoa Seca.**

**Source**: Agrometeorological study for the state of Paraíba. Medeiros (2016).

**Relative humidity**

Relative air humidity is defined as the relationship between the water vapor pressure and the saturation pressure of water vapor at room temperature.

The relative humidity of the air has a daily trend inverse to the air temperature. This is because the relative humidity of the air is inversely proportional to the vapor saturation pressure, which in turn is directly proportional to the temperature. The annual course of the relative humidity of the air follows that of the sky cover (amount of cloudiness) and the annual distribution of precipitation.

Normally, the relative humidity is lower during the day and higher at night. With the rising of the sun and with the increase in temperature, the relative humidity starts its downward course, reaching a minimum value when the maximum temperature occurs. From there, it starts its upward march following the decreases in air temperature, reaching its maximum value when the minimum temperature occurs.

It is noteworthy that the knowledge of the wetter season or wetter quarter is of fundamental importance for establishing the best planting time and conditions for storage and impoundment of water, particularly for the practice of rainfed agriculture.

Figure 4 shows the monthly variability of the relative humidity of the air for the municipality of Lagoa Seca.

The relative humidity of the air has little variability compared to the incidence of precipitation, it is also one of the parameters that act as a softener or neutralizer of the harmful effects of high temperatures, in addition to influencing the physiological processes of plants and the quality of fruits, grains and maintaining the most active vegetation in their water cycles during dry periods.

In short, we can observe that the relative humidity of the air for the municipality of Lagoa Seca has a monthly average ranging from 72.0% in October (lowest) to 87.0% in July (highest), with an annual rate of 77.0%.

The quarter with low relative humidity are the months of October, November, and December, and the months of March, May, June, and July are the wettest.

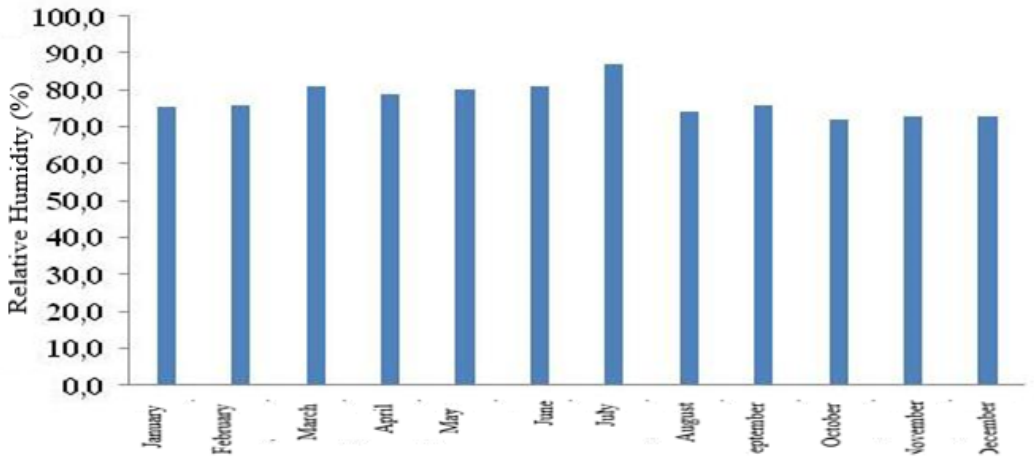


**Figure No. 4. Graph of the climatology of the relative humidity of the air, for the municipality of Lagoa Seca.**

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

**Winds (intensity and direction)**

The wind turns out to be the moving air. This amount of movement can be transferred to obstacles that interpose in the trajectory, causing damage of intensities proportional to the transferred "momentum". In a given area, damage ranges from an excessive stimulus to evapotranspiration to the mechanical effect of breaking branches and uprooting plants and trees. The most important aspect of wind action is restricted to the ground surface.

The atmosphere over any large area of the globe and especially in the mid-latitudes is characterized by a well-defined dynamic system, in which the movement of air is largely determined by the horizontal gradient of pressure and temperature. Wind can aggravate or attenuate the effect of other meteorological parameters, such as air temperature, maximum temperature, minimum temperature, and average temperature, relative air humidity, and atmospheric pressure, among others.

Light winds with speeds below 10.0 km/h can be beneficial, mainly by removing the humidity inside the crowns after the occurrence of rain and drying of dew, reducing the incidence of diseases and pests. Winds above 10.0 km/h are harmful, as they cause damage to plants whose

effects vary according to the intensity and duration of these winds, increasing the local rate of evaporation and contributing to a significant increase in the rate of evapotranspiration.

Figure 5 shows the graph of the climatological wind speed in meters per second for the municipality of Lagoa Seca.

The climatological wind intensity has monthly values between 2.47 to 3.52 m/s. The average annual wind intensity in this area is 1.6 m/s. It is observed that the climatological oscillation of the wind is quite irregular during the annual cycle. The months with the greatest fluctuations are from September to February with variations between 3.04 (lowest February) to 3.52 (larger October) m/s, while the months from March to July have the smallest monthly fluctuations between 2, 47 (April) to 2.96 (July) m/s.

We emphasize that in these calculations the wind gusts were not computed, a fact that occurs almost constantly when the high-pressure center in this region is stationary and permanent.

Winds help transport dust, pests, diseases, fungi, diseases, particles, wind erosion, fires, affect plant growth, influence evapotranspiration, and evaporation, and absorb carbon dioxide. These effects can be controlled in the municipal area, using wind barriers in places with higher slopes, always observing their predominant direction.

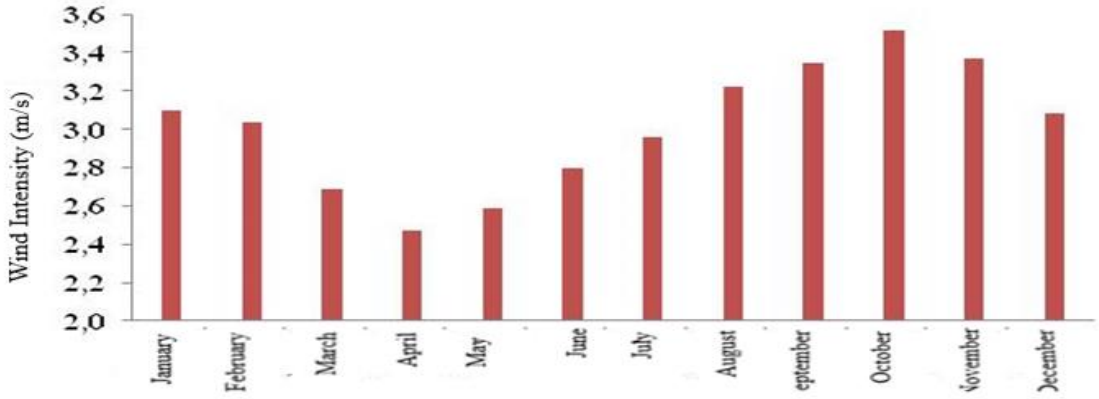


**Figure No. 5. Graph of the climatological wind speed for the municipality of Lagoa Seca.**

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

**Predominant wind direction**

The wind direction is the cardinal point where the wind comes from. From the compass rose, the prevailing wind direction for a given location and period is obtained.

The predominant wind direction is the direction that occurs most frequently. It results from the location of the location to the atmospheric pressure centers, being influenced by natural obstacles close to the ground. The relief has a very pronounced effect and can define the predominant direction.

By determining the prevailing wind direction in a region and/or location, it becomes easy to draw up the level curves for a land, the type of wind barrier, the control of fires and fires, the location of houses, buildings, dams, farms, orchards, pond for raising fish and shrimp, warehouses, leisure areas, entertainment and recreation, shows. This procedure can also contribute to the determination of ventilation and pest and disease control, using natural ventilation.

The prevailing average wind direction is quantified in two positions for ten months of the year, this means that most of the time the direction oscillates between one position and another. In these directions, relief was taken as a base, mainly in the interstate boundaries and places where there are sudden depressions since in these places the prevailing wind direction can relatively deviate from its standard direction.

The statement of the prevailing wind direction in the municipality is as follows, as shown in the table below:

**Table No. 1. Demonstration of the monthly and annual climatological direction of the predominant wind for the area of the municipality of Lagoa Seca.**

| Parameters/months | Wind direction |
|---|---|
| January | E-SE |
| February | E-SE |
| March | E-SE |
| April | E-SE |
| May | E-SE |
| June | SE |
| July | SE |
| August | E-SE |
| September | E-SE |
| October | E-SE |
| November | E-SE |
| December | E-SE |
| Yearly | E-SE |

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

The predominant annual wind direction in the municipality is E-SE. The predominant direction of E-SE occurs in January, February, March, April, May, August, September, October, November, and December. The SE direction is predominant in June and July.

It can be concluded that the factors causing rainfall are characteristic of the predominance of winds with a higher frequency of entry in the directions established above.

It is worth noting that the construction of wind barriers, against the spread of dust, fires, etc. should be carried out taking into account the predominance of the wind direction in this region. With the change in the wind direction on the surface, being associated with the occurrence of precipitation, this characteristic is of great importance for the municipal climate.

**Evapotranspiration**

The annual evapotranspiration in the municipality of Lagoa Seca is 1,776.1 mm, we observed that the fluctuation of this parameter from month to month varies from 99.1 mm (June lowest value) to 200.6 mm (December maximum value). The months with the lowest ETP values are April to June. The months with maximum values are from August to March, with fluctuations between 136.6 and 200.6 mm.

**Evaporation**

Figure 6 shows the graph of the climatology of evapotranspiration, evaporation (mm), for the municipality of Lagoa Seca. The annual rate of evaporation is 1,420.9 mm, very expressive when compared to the annual precipitation index. It is observed that the fluctuation of this parameter from month to month varies from: 79.3 mm (April) to 160.5 mm (December). The months with the lowest evaporation rates extend from April to July, with fluctuations between 79.3 and 86.6 mm. Between August and March, the evaporative indices flow between 109.3 to 160.5 mm.

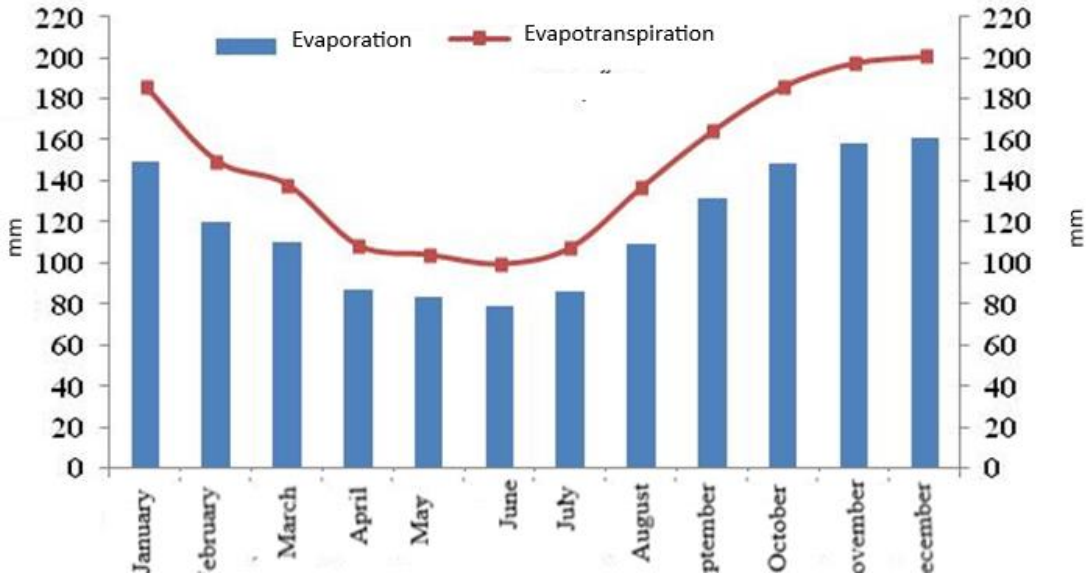


**Figure No. 6. Evaporation climatology graph, evapotranspiration for the municipality of Lagoa Seca.**

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

**Insolation**

Adequate information about the solar resource is very important for the diversity of technological areas, such as agriculture, meteorology, agricultural engineering, vegetables, legumes, fruit, forestry and civil, water/livestock resources, poultry, fish farming, shrimp farming, and particularly for innovative technology such solar energy. Accurately knowing the potential of the solar resource is a must.

The almost disorderly growth generates pressure on the use of natural resources and triggers a process of environmental degradation, putting at risk the issue of taking advantage of environmental resources.

The latitude of a place influences the amount of insolation received by the surface and, depending on the duration of exposure and the type of vegetation cover, defines the variations in insolation received, also being influenced by the altimetry quotas of the place.

The proper use of the insolation factor allows some practical applications to be carried out, such as the selection of varieties more adapted to the region, the choice of the most appropriate planting date, the control of the flowering time, the heating of water depths, avoiding in this way the reduction of evaporation rates is achieved.

Solar radiation is closely related to temperature and influences the yield and quality of citrus and grains, which tend to increase in good light conditions.

With behavior similar to other plants, citrus, when cultivated in dense planting (shaded), tend to grow a lot in search of sunlight, which is not good for production, because in the shaded part of the crown there is no flowering and the leaves become more sparse, culminating in the death of overshadowed branches.

The well-developed leaves, thickness, tissue density, specific weight, and nitrogen content of some citrus and grains have a greater contribution in case of full sunlight.

In the municipality of Lagoa Seca, it is observed that the incidence of heatstroke begins to decrease in the second half of March and continues to fall until the first half of July. half of March.

Figure 7 shows the climatological graph of total insolation (hours and tenths) and cloud cover (0-10), for the municipality of Lagoa Seca.

The annual sunshine duration is 2,557.4 hours. The months with the highest intensities of total insolation extend from August to March and from April to July, the rainy season, the intensity of insolation is reduced. Sunstroke acts inversely and proportionally to cloud cover.

**Cloudiness**

Total cloudiness is the fraction of the celestial canopy hidden by the set of visible clouds. With the records of meteorological observations of the types of clouds (cl) low clouds, (cm) medium clouds, and (ch) high clouds, using the number (0 – 10) it was possible to estimate the cloudiness for the municipality of Lagoa Seca.

It is observed that the highest concentrations of cloud cover are in December to September with fluctuations between 0.50 to 0.68 tenths. In October and November, there are 0.45 tenths of cloud cover.

The annual rate of cloudiness for the municipality of Lagoa Seca is 0.55 tenths of cloudiness.

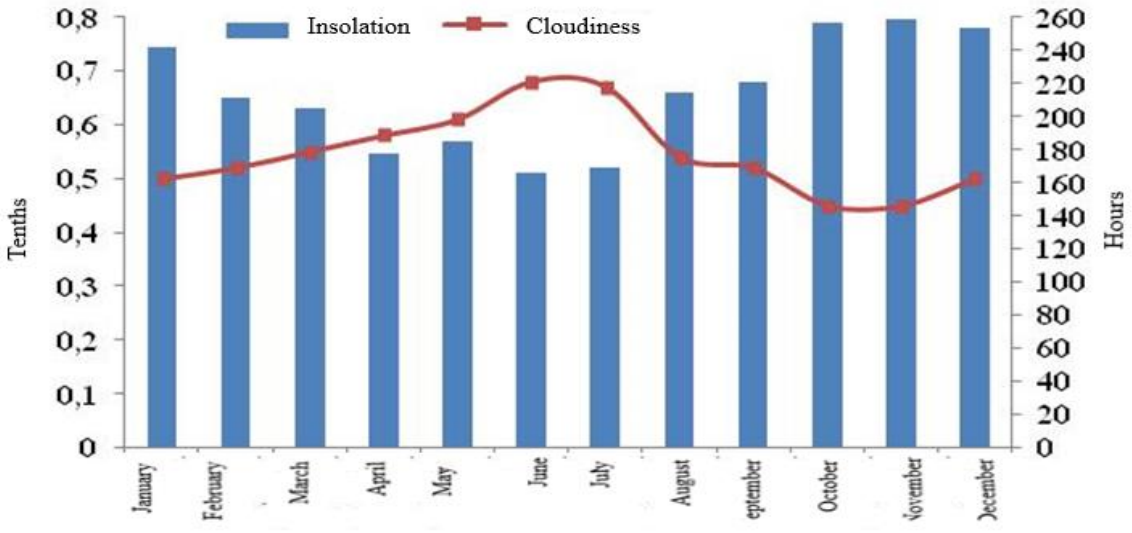


**Figure No. 7, Climatology graph of total insolation and cloud cover, for the municipality of Lagoa Seca.**

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

**Photoperiod**

Photoperiod or effective day length refers to the time the sun shines during the day. Depending on the position of the earth, there are regions with different amounts of hours of sunlight on the same day.

The maximum number of hours of sunlight (photoperiod) is an important parameter, both from a physiological point of view (it acts on the photosynthetic and morphological processes of plants), as well as from a physical point of view (it provides differential energy distribution for the same medium, throughout the annual cycle). It is known that the length of the day not only acts by shortening or increasing the plant's cycle but also on its chemical composition, formation of bulbs, tubers, fleshy roots, vegetative activity and rest, type of flowers, and resistance to cold.

The average annual photoperiod for the municipality of Lagoa Seca is 12:29 (hours and minutes). The months with the longest photoperiod are September, October, November, December, January, February, and March, ranging from 12:03 to 12:31 hours and minutes. The month with the shortest photoperiod is April, May, June, July, and August, with 11:42 to 11:57 hours and minutes.

**Table No. 2. Statement of the monthly and annual climatological database for the municipality of Lagoa Seca**.

| Par | Months | | | | | | | | | | | | YEARLY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | |
| 1 | 28,7 | 28,7 | 28,1 | 27 | 25,4 | 23,9 | 23,4 | 24,1 | 25,7 | 27,7 | 28,6 | 28,7 | 26,6 |
| 2 | 19,3 | 19,8 | 19,9 | 19,6 | 18,9 | 17,6 | 16,3 | 16,2 | 17 | 17,8 | 18,4 | 18,9 | 18,3 |
| 3 | 22,8 | 23,1 | 22,9 | 22,4 | 21,4 | 20,2 | 19,4 | 19,4 | 20,2 | 21,5 | 22,3 | 22,7 | 21,5 |
| 4 | 9,4 | 8,8 | 8,1 | 7,4 | 6,5 | 6,3 | 7,2 | 8 | 8,7 | 9,8 | 10,2 | 9,8 | 8,4 |
| 5 | 75,5 | 76 | 81 | 79 | 80 | 81 | 87 | 74 | 76 | 72 | 73 | 73 | 77 |
| 6 | 3,1 | 3,04 | 2,69 | 2,47 | 2,59 | 2,8 | 2,96 | 3,23 | 3,35 | 3,52 | 3,37 | 3,09 | 3,01 |
| 7 | E-SE | E-SE | E-SE | E-SE | E-SE | SE | SE | E-SE | E-SE | E-SE | E-SE | E-SE | E-SE |
| 8 | 148,8 | 119,8 | 110,4 | 86,6 | 82,9 | 79,3 | 85,7 | 109,3 | 131,2 | 148,7 | 157,9 | 160,5 | 1420,9 |
| 9 | 241,6 | 211,1 | 205 | 177,6 | 184,7 | 165,9 | 169,3 | 213,8 | 220,9 | 256,5 | 258,1 | 253,3 | 2557,4 |
| 10 | 0,5 | 0,52 | 0,55 | 0,58 | 0,61 | 0,68 | 0,67 | 0,54 | 0,52 | 0,45 | 0,45 | 0,5 | 0,55 |
| 11 | 56,2 | 81,2 | 124,5 | 143,5 | 138,2 | 181,2 | 167 | 110,3 | 41,4 | 21,8 | 21,7 | 25 | 56,2 |
| 12 | 10,8 | 9,4 | 11 | 13,4 | 14,8 | 20,5 | 18,6 | 16,2 | 9,2 | 5,7 | 5,7 | 5,7 | 139,6 |
| 13 | 12:29 | 12:20 | 12:09 | 11:57 | 11:47 | 11:42 | 11:44 | 11:52 | 12:03 | 12:15 | 12:26 | 12:31 | 12:29 |

LEGEND: PAR./MONTHS= Parameters/months; 1= maximum temperature (°C); 2= minimum temperature (°C); 3= Average temperature (°C); 4= Thermal amplitude (°C); 5= relative air humidity (%); 6= wind Intensity (m/s); 7= wind direction; 8= evaporation (mm); 9= total sunstroke (hours); 10= cloud cover (0-10); 11= climatological precipitation; 12= Rainy days; 13= Photoperiod.

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

**Hydric balance**

When more specific information is not available for the location where the production system is to be implemented, an available water capacity (DAC) of 50.0 mm is normally adopted for vegetable crops with a delicate root system, such as tomatoes, beans, cabbage, and a CAD of 100.0 mm for annual crops such as corn, or perennials such as citrus, from medium developed

root systems. The intermediate DAC's (25, 75, 125, and 150) are to be sure that we are not using water outside the crop standards and to see the variability of EVR, ETP, water deficit, and water surplus.

By analyzing the water balance data, in normal years, practically no difference is detected between the two situations of available water capacity in the soil, evidencing the viability of the cultivation of most crops in this region. On the other hand, in rainy years, there is no restriction, due to lack of water, however, there is concern about the excess, while in dry years the situation is unfeasible for any crop. It is observed that the annual rainfall regime, with a well-defined dry season, associated with poor distribution of rainfall during the rainy season and poor soil nutrients, in general, requires a high technical level for agricultural production, and it is recommended that adoption of management practices aimed at conserving water in the soil or irrigation.

The monthly and regional climatic water balance, as it uses only average values of average temperature and precipitation, cannot meet situations that arise where knowledge of different monthly and regional probabilities of occurrences of excess and deficiency of water is required. However, it produces useful results for the climatological characterization of the region and informs about the distribution of deficiencies and excesses of rain.

**Evapotranspiration**

Figure 8 – Shows the graph of climatological precipitation, potential evapotranspiration, and actual evaporation, according to THORNTHWAITE & MATHER for the municipality of Lagoa Seca.

The result of the water balance was obtained through the climatological temperature and average rainfall in the municipal area.

Table No. 3. Results of the water balance for the five CAD's in the municipality of Lagoa Seca, where DEF (water deficit) and EXC (water surplus).

The variability of water deficits in the DAC 's studied do not show advanced levels of significance, except for the DAC's of 100, 125, and 150 mm, in January, February, September, October, November, and December compared to the DAC 's of 25, 50 and 75 mm respectively.

The water surplus for the studied DAC 's occurs from April to August. The months of June, July, and August have the same surplus values in all CAD'S because the soil is already at its maximum field capacity, where the surplus flow begins, that is, for irrigated agriculture, any of these laminates used in this period causes excess as the soil already has field capacity. In April and May, the variability of the surpluses occurs in all changes of the DAC's, demonstrating that for irrigated agriculture and the type of planting, the appropriate DAC's were used.

Tables 1 and 2 show, respectively, the results of the water balance for the five DAC, as well as the results of the moisture, aridity, and water indices, for the DAC of 25 mm, 50 mm, 75 mm, 100 mm, 125 mm and 150 mm.

**Table No. 3. Results of the water balance for the five CAD's in the municipality of Lagoa Seca, where DEF (water deficit) and EXC (water surplus).**

| CAD | 25 | | 50 | | 75 | | 100 | | 125 | | 150 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | DEF | EXC | DEF | EXC | DEF | EXC | DEF | EXC | DEF | EXC | DEF | EXC |
| Jan | 42,0 | 0,0 | 41,7 | 0,0 | 40,6 | 0,0 | 38,8 | 0,0 | 36,6 | 0,0 | 34,4 | 0,0 |
| Feb | 12,1 | 0,0 | 12,1 | 0,0 | 11,8 | 0,0 | 11,4 | 0,0 | 10,9 | 0,0 | 10,3 | 0,0 |
| Mar | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| Apr | 0,0 | 52,6 | 0,0 | 27,7 | 0,0 | 4,1 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 | 0,0 |
| May | 0,0 | 56,2 | 0,0 | 56,2 | 0,0 | 56,2 | 0,0 | 39,3 | 0,0 | 21,0 | 0,0 | 5,4 |
| Jun | 0,0 | 113,1 | 0,0 | 113,1 | 0,0 | 113,1 | 0,0 | 113,1 | 0,0 | 113,1 | 0,0 | 113,1 |
| Jul | 0,0 | 103,5 | 0,0 | 103,5 | 0,0 | 103,5 | 0,0 | 103,5 | 0,0 | 103,5 | 0,0 | 103,5 |
| Aug | 0,0 | 45,5 | 0,0 | 45,5 | 0,0 | 45,5 | 0,0 | 45,5 | 0,0 | 45,5 | 0,0 | 45,5 |
| Sep | 11,4 | 0,0 | 6,7 | 0,0 | 4,8 | 0,0 | 3,7 | 0,0 | 3,0 | 0,0 | 2,5 | 0,0 |
| Oct | 56,2 | 0,0 | 43,2 | 0,0 | 34,3 | 0,0 | 28,2 | 0,0 | 23,9 | 0,0 | 20,7 | 0,0 |
| Nov | 69,7 | 0,0 | 64,3 | 0,0 | 57,0 | 0,0 | 50,2 | 0,0 | 44,6 | 0,0 | 39,9 | 0,0 |
| Dec | 74,3 | 0,0 | 72,9 | 0,0 | 69,0 | 0,0 | 64,0 | 0,0 | 59,1 | 0,0 | 54,5 | 0,0 |

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

Table 4 shows the fluctuations of the humidity, aridity, and water indices in Lagoa Seca Paraíba for the CAD's of 25, 50, 75, 100, 125, and 150.

**Table No. 4. Results of the humidity, aridity and water indices in Lagoa Seca, Paraíba**

| CAD's | humidity index | Aridity Index | Water Index |
|---|---|---|---|
| 25 | 36,80 | 26,40 | 21,00 |
| 50 | 34,37 | 23,94 | 20,01 |
| 75 | 32,03 | 21,59 | 19,07 |
| 100 | 29,93 | 19,50 | 18,23 |
| 125 | 28,12 | 17,68 | 17,51 |
| 150 | 26,57 | 16,13 | 16,89 |

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

The moisture and dryness indices show buoyancy of values in the respective CAD's studied for the water indices, we tested the CAD's of 75 and 100 mm, which provide the same values.

The graphics of the water balances for the CAD's of 25, 50, 75, 100, 125, and 150 mm and their representations of deficiencies, surpluses, removal of water replacement for the period 1981 to 2012 for the municipality of Lagoa Seca.

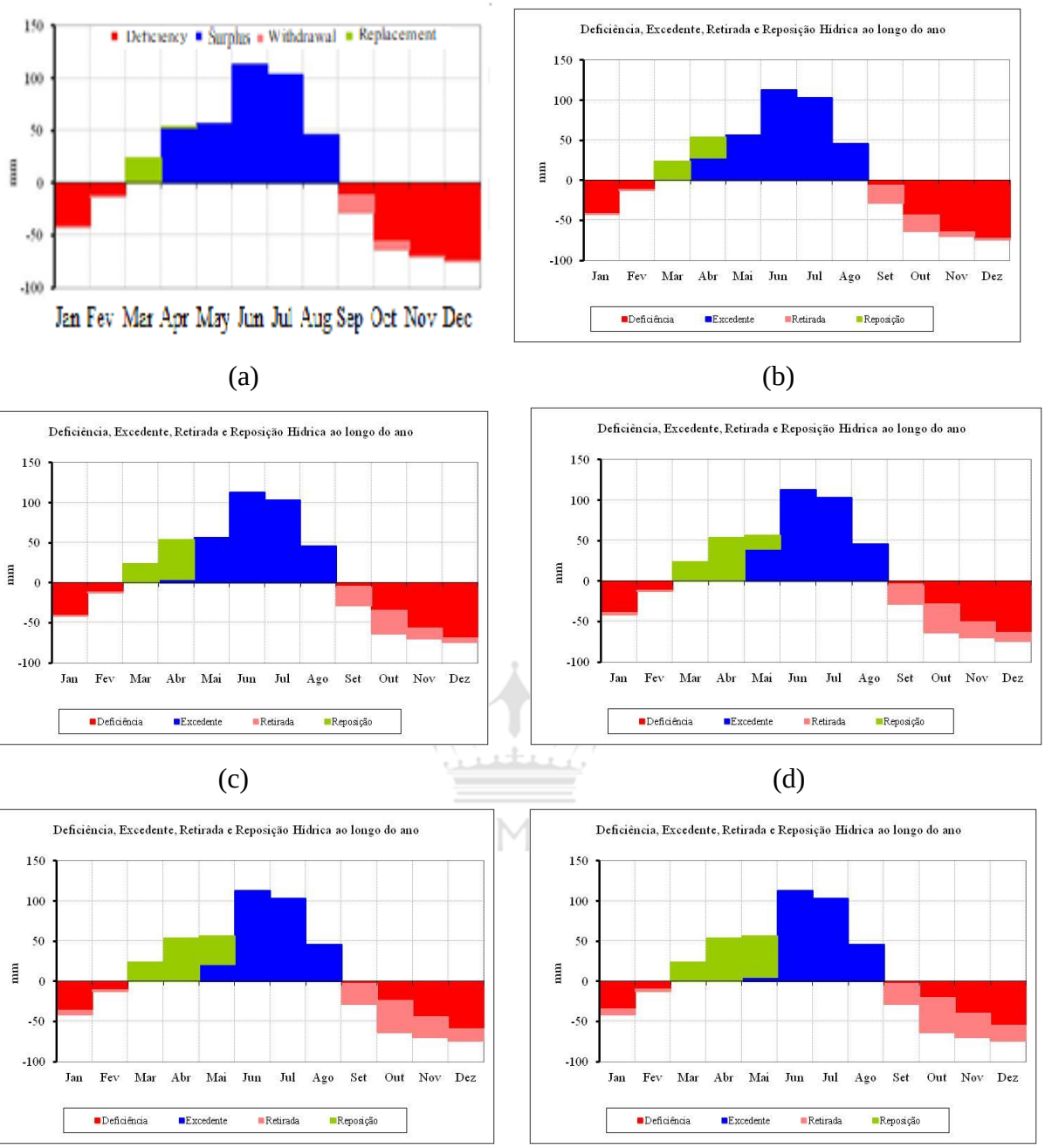


**Figure No. 8. Graphs of climatological precipitation, potential evaporation and actual evaporation, according to THORNTHWAITE & MATHER for the municipality of Lagoa Seca, (a)** DAC **25 mm; (b)** DAC **50 mm; (c) 75 mm CAD; (d)** DAC **100mm; (e)** DAC **125 mm and (f)** DAC **150 mm.**

**Source:** Agrometeorological study for the state of Paraíba. Medeiros (2016).

## CONCLUSIONS

The 25 mm, 50 mm, and 75 mm DAC 's are most suitable for working with vegetables and legumes; The 100 mm, 125 mm, and 150 mm CAD's are most suitable for banana plantations, fruit growing;

Using the DAC 's studied in the irrigation sector, there can be a reduction in electricity tariffs, time to reduce the use of water pumps, and rationalization of water applied to crops;

In cannon irrigation systems where DAC 's of 100, 125, and 150 mm are used, this is causing erosion and loading of fertile soils, so much in the part of fruit growing, vegetables, and legumes;

From April to August, irrigation should be carried out with a DAC of 25 mm;

Wind gusts greater than 10 ms-1 occur with greater predominance from August to February and can cause damage to legumes and vegetables in the studied area, such as lodging and defoliation;

The fluctuations in maximum, minimum, average air temperatures and thermal amplitude indicate the occurrence of possible dew formation above normal in almost every month of the year, with greater significance in March to August, a fact that may come to harm the quality of Horticultural products for the market;

The distribution of rainfall between March to August must be covered in the bed, thus avoiding lodging and defoliation of vegetables and legumes;

The relative humidity of the air, special care must be taken from October to December;

For the municipality of Lagoa Seca, there is abundant water, sun, and relative humidity suitable for the cultivation of lettuce, cauliflower, tomato, pepper, cucumber, arugula, spinach; cabbage, okra, chayote, gherkin, carrots, beetroot, zucchini, eggplant, cranberry, coriander, garlic, chives, pumpkin radish, pumpkin, as well as: sweet potatoes, yams, caraway, macacora, potato;

In fruit growing, the following stand out: banana, orange, lemon, lime, papaya, cashew, mango, guava, acerola, soursop, pine cone, jabuticaba, jackfruit, pitomba, caja, seriguela, melon, watermelon, Roma;

You can still have good yields with the planting of beans, corn, broad bean, grass, sorghum;

Climatic conditions are suitable for raising poultry, goats, beekeeping, fish farming;

It is still possible to plant and cultivate medicinal plants such as fennel; cinnamon; bold; clove; nutmeg; Holy grass; rue; anador; Rosemary; lemongrass; monkey; aloe; masthead; elderberry flower; hollyhock; white onion; gypsy thorn; gingerbread; blond; stone breakers; melon from São Caetano; foxtail;

Culinary herbs that are easy to plant and grow like: mints; various types of peppers; oregano; saffron; basil; thyme; parsley; sage; gingerbread;

To avoid certain pests and phytopathogens that evolve with plants, the ideal microclimate for the plant is usually ideal for pests, but if the plant is not stressed and can accumulate dry matter, it tends to become more resistant to diseases, since Soil temperature and moisture are being controlled, factors that help in the development of pests and stress on cultivars.

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