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DETERMINATION OF WATER INTAKE OF RED PIGEON (*Combretum lanceolatum Pohl*)

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ABSTRACT

The Pantanal is located in the Upper Paraguay Depression, it is characterized by being the largest floodplain in the world, with alternating floods and droughts. During the last decades, economic changes and political requirements have increased the pressure on the Pantanal and its hydrographic basin, due to transformations in land use and occupation with agriculture. Its natural grasslands have a great diversity of habitats that include grasslands, savannahs and forests under different flood regimes. These conditions directly contribute to the development of Combretum lanceolatum Pohl, also known as Red Pombeiro, being considered a monodominant species, a considerable increase was observed in the Pantanal grasslands. Knowing the characteristics of water consumption of this species in response to atmospheric demand effectively contributes to the understanding of its physiological characterization and, mainly, its management. Therefore, this study aimed to determine the water consumption of Combretum lanceolatum Pohl (Red Pigeon). The study was conducted in an area adjacent to the Meteorological Station Pe. Ricardo Remeter, belonging to the INMET network, in Santo Antônio de Leverger-MT, who provided macrometeorological data: maximum and minimum temperatures, wind speed, rainfall, insolation and evaporation, daily. Water consumption (evapotranspiration) was measured by the constant water table lysimeter method, where there were six pots containing the Red Pombeiro plants, which had their values modeled by multiple linear regression together with estimates of Reference Evapotranspiration from the Penman-Moteith aerodynamic method and with the leaf area. The evapotranspiration rates had a higher correlation with the leaf area index than with the reference evapotranspiration.

Keywords: Micrometeorology, Evapotranspiration, Lysistry, Leaf Area.

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INTRODUCTION

The flow of water in forest environments, whether in natural environments or in plantations controlled by human activity, depends on the rainfall regime of the region, the species of plant, the interception of water by the canopy, surface and depth runoff, and evapotranspiration. Most of these processes are directly influenced by the type of soil, the typical physiology of the plant and the structure and architecture of the canopy (Almeida and Soares, 2003). Evapotranspiration (ET) depends on soil moisture, atmospheric demand (vapor pressure deficit) and mainly on available solar radiation, a variable related to latitude but also modified, in a forest system, by the plants themselves (Campelo Júnior and Souza; 2009 Angelini et al., 2017).

Combretum lanceolatum Pohl is an angiosperm present throughout Brazil and Paraguay. It has a pantropical distribution adapting to both wetter and dry environments. Its genus groups about two hundred species (Exell, 1953).

Pollination is usually of the entomophilia type, with bees and other insects as the main pollinating agents. The gelatinous secretion of the plant is consumed by thirty-eight (38) species of birds in the Pantanal, the most frequent consumers being *Paroaria capitata* and *Pitangus sulphuratus* (Silva; Rubio, 2007).

This vegetable has adapted to the peculiar conditions of the Pantanal, managing to survive both in times of drought and in times of floods. The pombeiro is a woody vegetable that has invaded the Pantanal in recent decades. Taxonomically it belongs to the Combretaceae family , and is also known as jamarataia, monkey remela or dove remela. It usually reaches less than two meters, having ornamental potential. It is distributed mainly in the forests of the mountain ranges. It can be found on the banks of rivers and swampy areas. Its flowers are light green and produce a nectar with high carbohydrate content that serves as food for birds and insects. Flowering occurs between the months of April and August and fruiting is observed between the months of August and November. In pasture areas, the presence of the pombeiro improves diversity, attracting other animals such as hummingbirds, pigeons, Pantanal aracuã, parakeet, insects and others.

The rhythm of the evaporation and transpiration processes determine the water supply available to the plant and are affected by the availability of energy resulting from interactions with the Earth's atmosphere and with meteorological variables that influence the processes of energy dissipation and maintenance of the metabolism necessary for the growth and development of the plant (Pereira et al., 1997; Danelichen et al., 2020).

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Knowing the ET data of a given crop is necessary for physiological characterization of plants, management and sizing of irrigation projects. Which are generally obtained using models that estimate ET from meteorological data. Among the methods for estimating ET, energy balance (Bowen's ratio) and aerodynamic (Penman-Monteith) methods are universally used (Pereira et al., 2021) but do not provide accurate ET calculations, since they are calculated indirectly by mathematical models. Another method that has been used in precision agriculture is remote sensing, which obtains good ET estimates at a reduced cost (Gomes et al., 2021), but the process includes calibration (data validation) that is required for each species.

Lysimetry methods are more accurate, as they measure TS and are therefore necessary instruments in the validation of models that estimate TS (Bégué et al., 2018).

Thus, the objective of this work was to determine the water consumption of *Combretum lanceolatum Pohl* (Red Pombee) by means of constant water table lysimeters.

MATERIAL AND METHODS

The lysimeters were installed adjacent to the Pe Ricardo Remetter meteorological station, Experimental Farm of the Federal University of Mato Grosso (UFMT), located in the municipality of Santo Antônio do Leverger-MT, located at the following coordinates: 15°47'5" S latitude, longitude 56°04' W, about 140 meters above sea level. The farm is located in a formation known as the Cuiabana Depression, with an Aw climate, according to the classification of Köppen (1948). It has typical vegetation of the Brazilian Cerrado, dystrophic litholic soils, concretionary (Plintosols), occasionally epigravel (Seixas, 2009). The average annual rainfall is 1320 mm (Seixas, 2009). The place is approximately 33 kilometers from the capital Cuiabá-MT.

The Reference Evapotranspiration was obtained using **Equation (1).**

$$ET_0 = \frac{0,408.\Delta.(R_n - G) + \frac{\gamma.900.U_2.(e_s - e_a)}{T+273}}{(\Delta + \gamma.(1+0,34.U_2)} \quad \textbf{(1)}$$

Where is evapotranspiration reference (mm/day), is the psychrometric constant (kPa/ºC), is derived from the water vapor saturation function (kPa/ºC), is the useful radiation received by the reference crop (MJ/m$ET_0 \gamma \Delta R_n$2day), G is the heat flux received by the soil (MJ/m2 x day), is the wind speed at 2m height (m/s),   is the average temperature of the air in the month (º C), is the water vapor saturation voltage (kPa), is the current water vapor tension (kPa), is the saturation vapor pressure deficit (kPa).$U_2 T e_s e_a e_s - e_a$

Peres (1994) states that Penman developed his equation considering the speed of the wind, relating it to the surface of free water, based on two rules: 1) that the sources and sinks of sensible heat occur in the same plane, for example, the blade of a leaf; 2) That the vapor pressure of the evaporating surface is equal to the vapor pressure of saturation of the water at the surface temperature. Penman did not consider important elements in his original equation, which is why the equation, combined with the term aerodynamics and surface strength of a plant canopy, came to be called the Penman–Monteith equation.

The effect of radiation on plants is related to wavelength. Very short waves (below 0.28 nm) usually have a deleterious effect. Photosynthesis performs best in waves ranging from 0.40 to 0.51 nm, which in the visible spectrum correspond to indigo and blue colors. This effect is explained by the better absorption of chlorophyll and xanthophyll to radiation included in this range.

Radiations with a length between 0.51 and 0.61 nm exert little or no influence, which can be explained by the reflection of the photosynthetic pigments in green and yellow colors that are included in this range.

The unit typically used to measure radiation is the Watt (W). The World Meteorological Organization (WMO) recommends both the use of Watt per square meter (W.m-2) in the measurement of both emittance (flux emitted per unit area) and irradiance (incident flux per unit area). Emittance and irradiance are usually represented by Me and Ee, respectively.

The sun is the energy source that sustains photosynthesis and provides the energy necessary for the processes of evaporation and transpiration. The solar energy incident on the earth is called global radiation and is divided into direct radiation (that emanating from the solar disk) and diffuse radiation (resulting from the action of scattering the atmosphere that deflects the rays before they reach the surface).

Because there is a relationship between solar radiation and insolation (solar brightness), which is different for each location and for each time of the year, statistical models were developed to estimate it from the insolation data. The first estimation model was published by Angströn (1924). Prescott (1940) simplified the Angströn (1924) equation so that, from the linear and angular coefficients of the simple linear regression equation

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between the insolation ratio and global solar radiation, it was possible to estimate the global solar radiation, based on the insolation data, and the model was called Angströn-Prescott. (Dantas et al, 2003)

Global Solar radiation was estimated using **Equation (2),** Campelo Júnior (1998).

$$Q_g = Q_0(a + b)\frac{n}{N} \quad \textbf{(2)}$$

Where: Q_g is the global solar radiation measured in , is the solar radiation at the top of the atmosphere , $(W.m^{-2})Q_g(W.m^{-2})n$represents the hours of actual insolation), is the maximum possible duration of the sun's brightness), $(h.d^{-1}N(h.d^{-1}$*a* is the coefficient that expresses the fraction of radiation at the top of the atmosphere that reaches the Earth on totally cloudy days, corresponding to the diffuse fraction, and *b* is the complementary coefficient that expresses the total global solar radiation.

The estimates of and N were obtained using Q_g**Equations (3) to (7)** (Pereira et al., 2002).

$$Q_g = 37{,}586\, D(\omega_s sen\, \varphi + \cos\varphi \cos\delta\, sen\omega_s) \quad \textbf{(3)}$$

$$D = 1 + 0{,}0033 \cos\left(J\frac{2\pi}{365}\right) \quad \textbf{(4)}$$

$$\omega_s = cos^{-1}(-tan\varphi - tan\delta) \quad \textbf{(5)}$$

$$\delta = 0{,}4093 sen\left(J\frac{2\pi}{365} - 1{,}405\right) \quad \textbf{(6)}$$

$$N = \frac{24}{\pi}\omega_s \quad \textbf{(7)}$$

Where: is the relative distance from Earth to Sun, the hour angle of sunset (rad), the latitude of the location (rad), the solar declination (rad), and the number of the day of the year.$D\omega_s\varphi\delta J$

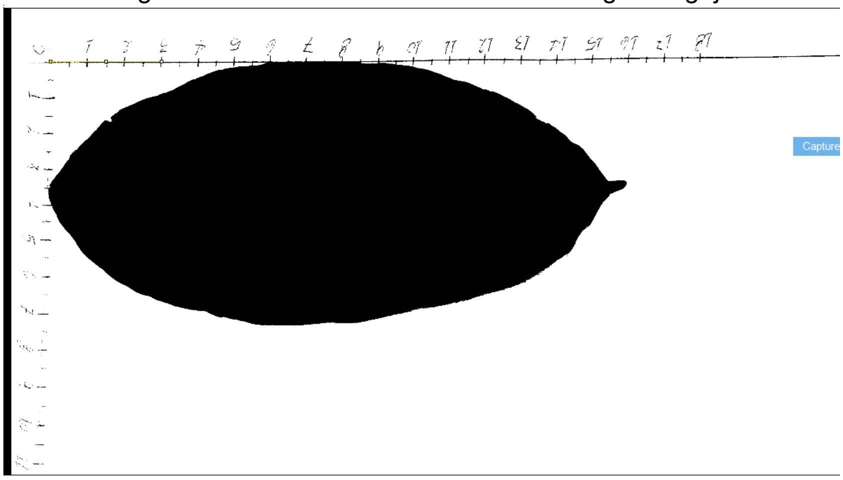
The Angström-Prescott coefficients and coefficients were obtained from estimates of global solar radiation by means of the Angström-Prescott equation made by Campelo Júnior (1998).$a = 0{,}21 b = 0{,}44$

RESULTS AND DISCUSSIONS

The evapotranspiration of a plant depends simultaneously on factors linked to the characteristics of the plant itself and climatic factors (Galvíncio et al., 2020). Among the climatic factors is solar radiation, responsible for supplying energy for the process to occur, the temperature and relative humidity of the air that together determine the vapor pressure deficit near the evaporating surface and the wind speed, responsible for the exchange of the air layer near the evaporating surface under study (Pereira et al., 2013). Another important parameter is the leaf area index (*LAI*) is defined as the ratio between the total leaf area of the canopy and the surface on the ground covered by these leaves (Posse, et al., 2009). It is one of the main components of an ecosystem's biochemical cycles as it can determine the microclimate below and above the tree canopy (Lima, 2015).

The determination of the leaf area of the species studied was carried out using the Imagej Software as shown in **figure 1**.

Figure 1: Determination of leaf area through Imagej



Source: Prepared by the authors (2023)

The value of the average leaf area was determined by calculating the area of thirteen medium-sized leaves taken from the six specimens in **Table 1 using Imagej**.

Table 1: Average values of leaf area of the thirteen leaves used as a parameter

Leaf	Area (m²)
1	0,0080707
2	0,0050055
3	0,0052189
4	0,0058120
5	0,0052450
6	0,0059304
7	0,0043309
8	0,0057396
9	0,0075649
10	0,0059858
11	0,0039842
12	0,0033356
13	0,0051892
Average	0,005494

Source: Prepared by the authors (2023)

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Leaf area (FA) data were obtained directly by multiplying the value of the average leaf area (FMA) by the number of leaves of each individual of *Combretum lanceolatum*.

Leaf area data were found for each of the specimens analyzed, **Table 2**.

Table 2: Adjusted equations for each specimen evaluated

Plant	Representative leaf area (m²)	No. of sheets	Leaf area (m²)
1	0,0055	220	1,2087
2	0,0055	254	1,3955
3	0,0055	310	1,7031
4	0,0055	352	1,9339
5	0,0055	219	1,2032
6	0,0055	322	1,7691

Source: Prepared by the authors (2023)

The results obtained for *Combretum lanceolatum* in this work were similar to those found by Biudes et al. (2011) for *Hancornia speciosa* Gómes in Santo Antônio do Leverger-MT, Pivetta (2007) for tomatoes and peppers in Rio Grande do Sul, Rojas (2003) studied citrus in São Paulo, Pimentel et al. (2010) in coffee plants in Pernambuco among others. The estimation of leaf area is commonly used in agronomic and physiological studies in order to evaluate plant growth. Several methods have been used to measure leaf area, usually with the use of electronic meters and planimetry techniques (KVET AND MARSHALL 1971), WHICH ARE EXPENSIVE AND COMPLEX AND DIFFICULT TO ACCESS. IN THIS SENSE, THE MATHEMATICAL EQUATIONS FOR ESTIMATING LEAF AREA WERE DEVELOPED IN THE SEARCH FOR AN EASY AND FAST METHOD OF EXECUTION.

The average water consumption was measured in the period between 08/27/12 and 12/28/12, in view of the greater consistency of the data obtained. In this interval, the water demand fluctuated between 0.03 L and 13.96 L per day.

Reference evapotranspiration (Eto) was estimated by the Penman Monteith method for the same period and ranged from 1.64 mm to 54.59 mm per day. It was possible to verify a positive linear correlation between these quantities that obey the model y = 0.90x + 15.76. This correlation showed R2 = 0.11, which means that the model is inadequate **, figure 2**.

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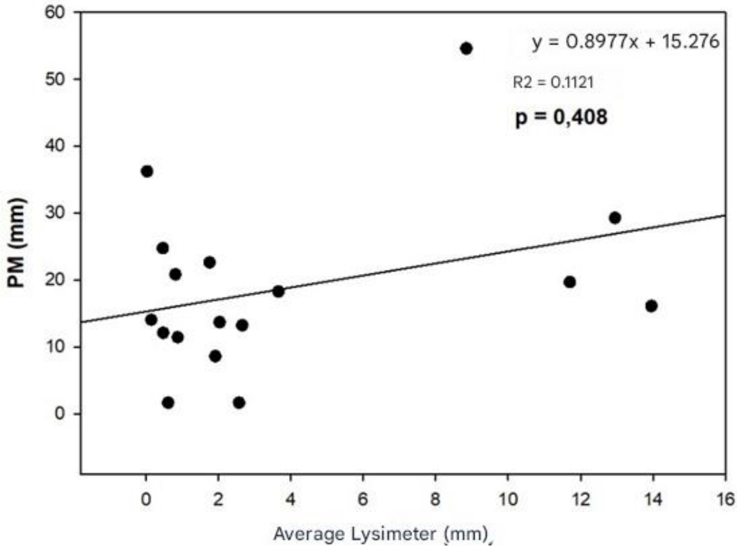
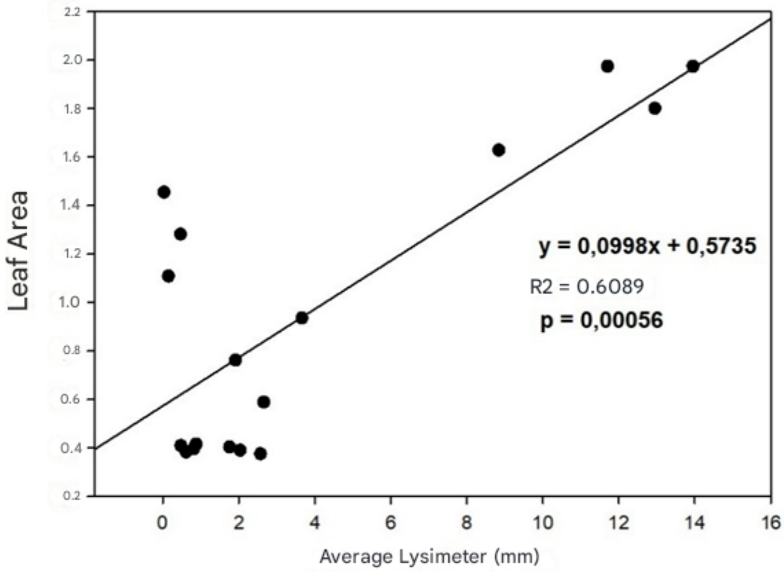
Figure 2: Multiple linear regression between water intake and Penman Monteith's reference evapotranspiration for Combretum Lanceolatum



Source: Prepared by the authors (2023)

The average leaf area shows a positive linear relationship with the water consumption measured by the lysimeters. In this case, the equation obtained was y = 0.099x + 0.573 with R2 = 0.61, which means that the equation is significant and that the leaf area determines, approximately 61%, of the water consumption for *Combretum lanceolatum* as shown in **figure 3**.

Figure 3: Multiple linear regression between water intake and average leaf area for Combretum lanceolatum



Source: Prepared by the authors (2023)

In (**Figure 4**), it was possible to verify the positive and proportional relationship between these data of water consumption and leaf area for *Combretum lanceolatum*, which

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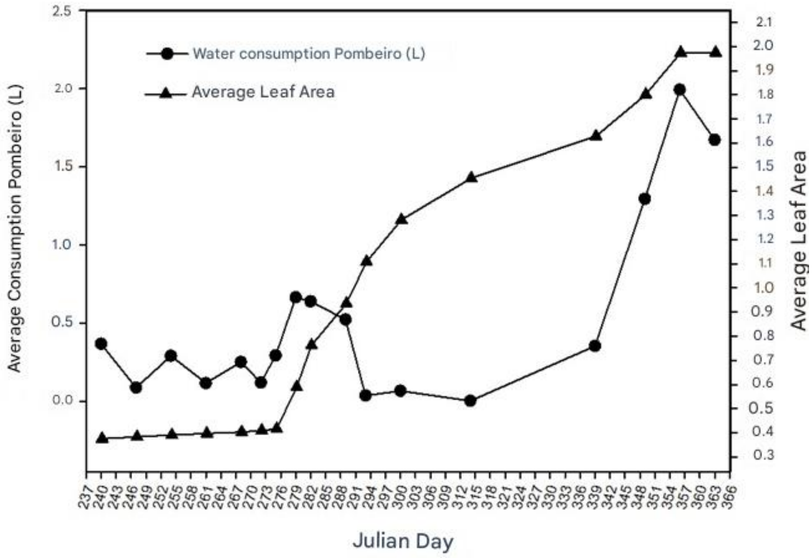
can be explained by the fact that the leaves are the plant organs that house the stomata, the main structures in which transpiration occurs. In summary, more leaf area means more stomata and, therefore, more capacity to lose water to the environment.

Figure 4: Average daily variation of water intake and leaf area for *Combretum lanceolatum* in Santo Antônio do Leverger - MT



Source: Prepared by the authors (2023)

The average transpiration in liters per day and the average transpiration in liters per day by the ratio obtained from the leaf area can be seen in **Figure 5**. It was verified that from day 312, measured data, there is an inversion in the upward curve. It can be seen that the average sweat starts to present higher rates. This means that from this moment on, transpiration and, consequently, water consumption, is conditioned by meteorological factors and not so much by the surface of the leaf area.

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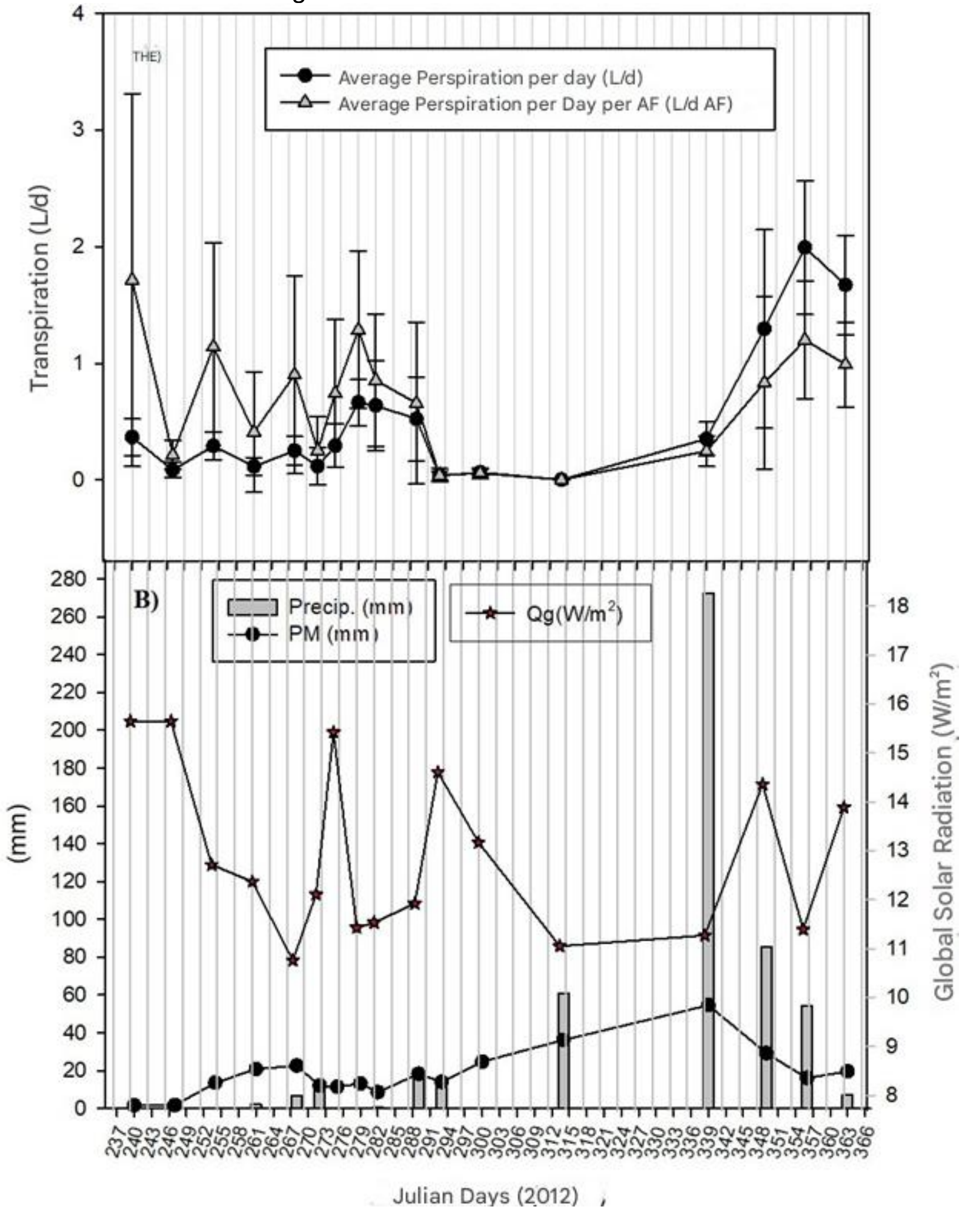
Figure 5: Average transpiration per day, average transpiration per day by average leaf area (a), variation of solar radiation with precipitation and reference evapotranspiration from Penman Monteith (b) to Combretum Lanceolatum in Santo Antônio do Leverger – MT



Source: Prepared by the authors (2023)

We can observe in (**Figure 5 – B**) that there is a positive correlation between transpiration and global radiation. This reinforces what is well known that the main source of energy that moves water in the soil-plant-atmosphere system is transpiration correlated with solar radiation. It can be seen from the graph that even in rainy periods, where there are lower values of global radiation, evapotranspiration remained high. This can be explained by the period of the year with high temperatures. In addition to the fact that in the technique used the constant water table lysimeter, water is a supply that is always available, with the plant not having deprivations, even in periods when there is no rainfall.

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CONCLUSIONS

In this work we can conclude that:

The water consumption of *Combretum lanceolatum* in Santo Antônio do Leverger - MT can explain 62.8% by the variation of PA and PM in P-value = 0.00098 of significance.;

Leaf area is the main variable related to the water consumption of *Combretum lanceolatum* in Santo Antônio do Leverger – MT;

Pereira's model (y = 0.099x + 0.573) was accurate to estimate the water consumption of *Combretum lanceolatum* in Santo Antônio do Leverger – MT.

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