Climatic Behavior of São Miguel do Iguaçu - PR

Doglas Bassegio[1], Reginaldo Ferreira Santos[1,2], Deonir Secco[1], Samuel Nelson Menegari de Souza[1] e Elisandro Pires Frigo[1]

[1]Universidade Estadual do Oeste do Paraná – UNIOESTE, Curso de Pós Graduação Stricto Sensu em Energia na Agricultura. Rua Universitária, n.2069, CEP: 85.819-110, Bairro Universitário, Cascavel, PR.
[2] Faculdade Assis Gurgacz – FAG, Curso de Agronomia.

doglas14@hotmail.com, reginaldof@fag.edu.br

Abstract: The study aims to estimate the reference evapotranspiration (ET_0) monthly to the municipality of São Miguel do Iguaçu - PR, by the method of Hargreaves and Samani (1985). Values (ET_0) are needed in the management of irrigated agriculture, have several models in the literature to estimate, but farmers advocate methods simpler and less laborious. We used historical data of average monthly air temperature and rain during the period 1983 to 1997, from a weather station of IAPAR located at latitude 25 º 20'53"S, 54 º 14'16"W longitude and altitude 307m above sea level, in São Miguel do Iguacu, Paraná State. The data were processed with the aid of a spreadsheet to estimate evapotranspiration. ET_0 values range from 63 mm to 176 mm, and between the months April to September had the lowest values of ET_0 caused by thermal restriction in the region, while the months from October to March have the highest values of ET_0.

Keywords: temperature, rainfall and Hargreaves.

Introdução

The municipality of São Miguel do Iguaçu is located in the west of Paraná State, belongs to the 21th of the micro state and the third plateau of Paraná State, it has a considered slightly undulating topography (Mulinari, 2007). The region's agricultural potential and its main crop soybean and corn crops demanding in water management.

The evapotranspiration is directly linked to various physical processes of soil and stages of culture (Lemon *et al*., 1957). It is considered the accounting equivalent amount of water evaporated per unit time of a living organism, usually expressed as amount of water per unit time (Burman *et al*., 1983). For Sentelhas and Angelocci (2009), the evaporation process is the transfer of water to the atmosphere and transpiration of the evaporation plant soil.

Most models of estimative the evapotranspiration was developed in temperate areas. There are many models available in the literature to estimate evapotranspiration, however, the lack of information on evapotranspiration in tropical regions has led to situations where he has used models to estimate evapotranspiration without any prior knowledge of its applicability to the environment local conditions (Amarakoon *et al*., 2000).

Knowing values of quantitative evapotranspiration is of great importance in there realization of projects and irrigation management with the focus view in production and quality of the product, with maximum efficiency and knowledge of the parameters soil-water-plant-atmosphere. In irrigated crops, an error in the determination of crop evapotranspiration may provide surplus or deficit of water, which can damage crops and raise the cost of production (Oliveira, 2010).

It is known that all fresh water surface of the world (0.643% of water around the globe), only 51.8% (0.333% of total) is available for use. Of freshwater that is actually used, 70% are in practice used for irrigation. Hence the importance of rational and sustainable management of water resources in agriculture (Sentelhas and Angelocci, 2009).

Potential evapotranspiration (ETP) or reference (ET_0) is the evapotranspiration of a large area with low vegetation (usually grass) in active growth, completely covering the ground with a height between 8 and 15cm with IAF ≈ 3 (3.0 m^2 of leaves per m^2 of land), without water restriction and wide area boundary to prevent heat advection (Bergamaschi *et al*., 1999). For Thornthwaite (1948) is the water evaporated from a surface completely covered with vegetation and uniform without suffering water stress. Already Sellers (1985) states that evapotranspiration is as a process in which plants play an active role and auto-regulator in their energetic losses through the leaves. Allen *et al*. (1994) says that the grass was chosen ET_0 work estimates, because their features are more defined, easily adapted and available for validation of new models.

According to Bouchet (1963) differs from the actual evapotranspiration potential for significant change of vegetation cover and the actual conditions of water supply in the soil. The water needs of crops are expressed in terms of evapotranspiration in mm / day or mm / season. The actual evapotranspiration (ETr) is equal to the maximum evapotranspiration (ETM), when the soil has abundant water and less water when the soil is limited (Doorenbos and Kassam 1994).

According Bernado *et al*. (1996) to ET_0 can be determined by direct and indirect methods. Evapotranspiration can be measured with lysimeters or tanks vegetated evapotranspirometers being called a direct method. But despite its excellent results, it shows a very high cost equipment, becoming impractical its use in the management of irrigated agriculture in everyday life (Gonçalves *et al*., 2009). According Sentelhas and Angelocci (2009) because it is a laborious determination, the ET_0 can be obtained from meteorological data observed in conventional or automatic meteorological stations.

Among the several methods of empirical equations have the methods of Thornthwaite, Thornthwaite-Camargo, Camargo, Hargreaves and Samani, a Class A tank, Priestley-Taylor and Penman-Monteith. For Moura *et al*. (2001) the use of irrigation management using the tank class A, which is based on evaporation of a free area, may underestimate the water consumption in subtropical climates, it includes in the calculations low evaporation occurred on rainy days, while the irrigation is carried out in periods of water shortage and higher evaporation. When making irrigation management, based on this equation (1) in the rainiest months, can result in inaccurate estimates, which can lead to wasting water and energy expenditure (Scaloppi and Saad, 1988).

Empirical methods, according to Penman (1963), have limitations because they are simple methods, but they are still being used, because they have values as accurate as those obtained from direct field, which facilitates irrigation management and offers greater practicality for the producer. According Sentelhas and Angelocci (2009), the method of Hargreaves and Samani (1985) allows the determination in arid and semiarid climate northeastern of Brazil, its disadvantage is shown in humid climates where you can overestimate the values. However, for the region of São Miguel do Iguaçu, PR, the driest months in the region has a water deficit are the most important for summer crops, highly dependent on rain.

According to Gonçalves *et al*. (2009) in a study seeking the correlation between the method Penman-Monteith-FAO & Hargreaves and Samani (1985), to estimate the reference evapotranspiration for the city of Sobral, Ceará, as an alternative simple farmers, showed that the Hargreaves and Samani method presented a better confidence index, which is important in determining the reference evapotranspiration. Conceição (2003) also doing work in the estimation of reference evapotranspiration in the Lower Rio Grande in the State of Sao Paulo found confidence index of 0.82 for the method of Hargreaves-Samani (1985), classified as very good. Similar results were reported by Singh *et al*. (2010) using the method of Hargreaves, Samani (1985).

Although evapotranspiration is an important component in the water balance, for help in quantifying the calculation of water demand in a region, the more accurate methods are expansive and difficult to apply in the field. For Vianello and Alves (1991) as the Brazilian territory is extensive and there is the difficulty of financial resources, particularly in regions farther from the center of the country and in areas of family farming, it should go through with the use of empirical formulations in which take the various conditions in the environment variables measured. There are different methods with regard to their application and their limitations, however, the estimated average monthly reference evapotranspiration by the method of Hargreaves and Samani (1985) for dry periods, is one of the most advised because it requires only tables already available in literature and radiation thermometer.

According to Doorenbos and Pruitt (1977), the same methods with a more theoretical basis as is the Penman - Monteith method used by FAO (Food and Agriculture Organization) has many disadvantages and required input temperature (T), relative humidity air (RH), solar radiation (Rs) and wind speed (V) becoming unaffordable for many local and farmers. The greatest care in a sustainable irrigation management is to define accurately the needs of the culture water, the blade will implement and timing of application (Gonçalves *et al*., 2009). Nowadays studies on evapotranspiration are advanced, but with the rapid growth of newcultivars carrying genetic methods require updating evapotranspiration continues to look for sustainability of irrigation always trying to preserve natural areas and lower environmental waste water (Nunes, 2006).

The objective of this study is to estimate the average monthly reference evapotranspiration reference by the method of Hargreaves and Samani (1985) for the municipality of São Miguel do Iguaçu, PR, to better characterize the region's climate.

Material and Methods

Data were obtained from the meteorological station of São Miguel do Iguaçu, the station code registered in ANEEL.: 02554026 belonging to the Agronomic Institute of Paraná -IAPAR, located at latitude 25 º 26 'S, longitude 54o22'W and 260m above sea level. The municipality is classified according to the method of Köppen and Geiger (1928) in Cfa. The observation period was between 1983 the 1997. After tabulating the data in Excel spreadsheet editor © procedures were carried out to determine the values of ET_0.

Was chosen for the following work the empirical method Hargreaves and Samani (1985) developed for the region of dry weather. Is based on the average air temperature and temperature range. Has the advantage of its applicability in arid and semiarid climates such as in northeastern Brazil. The disadvantage is their limited use for such conditions, with overestimation in humid climates (Sentelhas and Angelocci, 2009).

$$ETP=0,0023\ Q_0\ (Tmáx - Tmín)^{0,5}\ (Tméd + 17,8) \qquad (1)$$

ETP - evapotranspiration ($mm.d^{-1}$)

Q_0 - coefficient of extraterrestrial solar radiation average month for each mm of evaporation equivalent.

Tmax - monthly average maximum temperature in ° C.

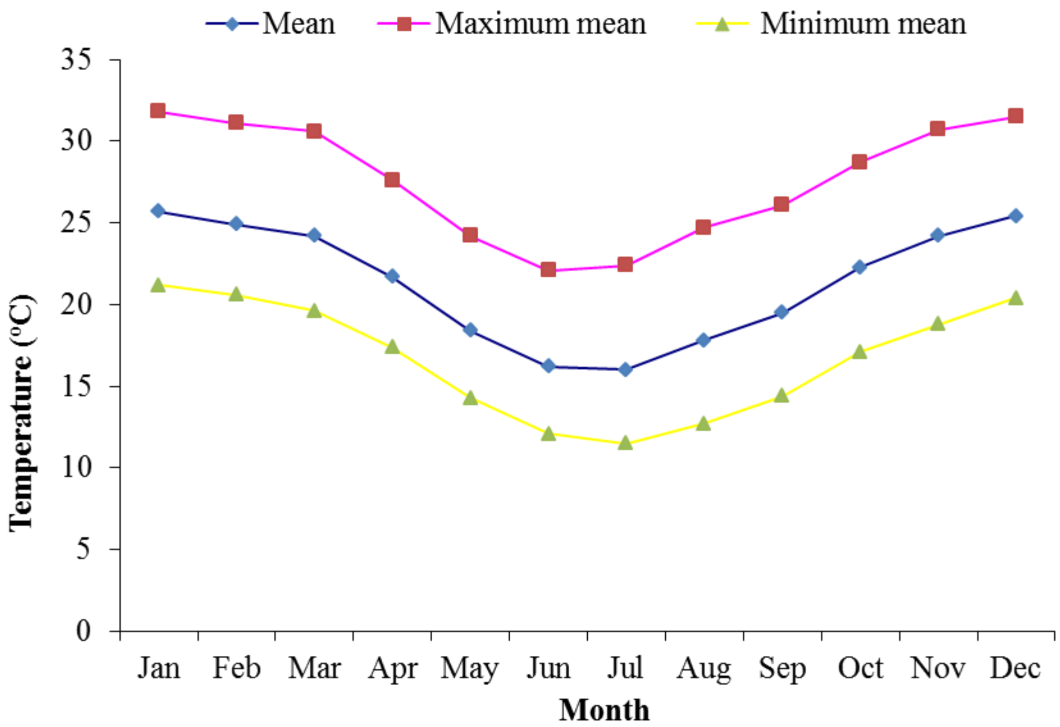
Tmin - mean monthly minimum temperature in °C.

T - mean monthly temperature in °C.

Results and Discussion

After processing and analyzing the data obtained were the average monthly temperature and precipitation. Temperature is an important variable in the process of evapotranspiration, despite the temperature interferes directly the productivity and the development and flowering of certain crops.

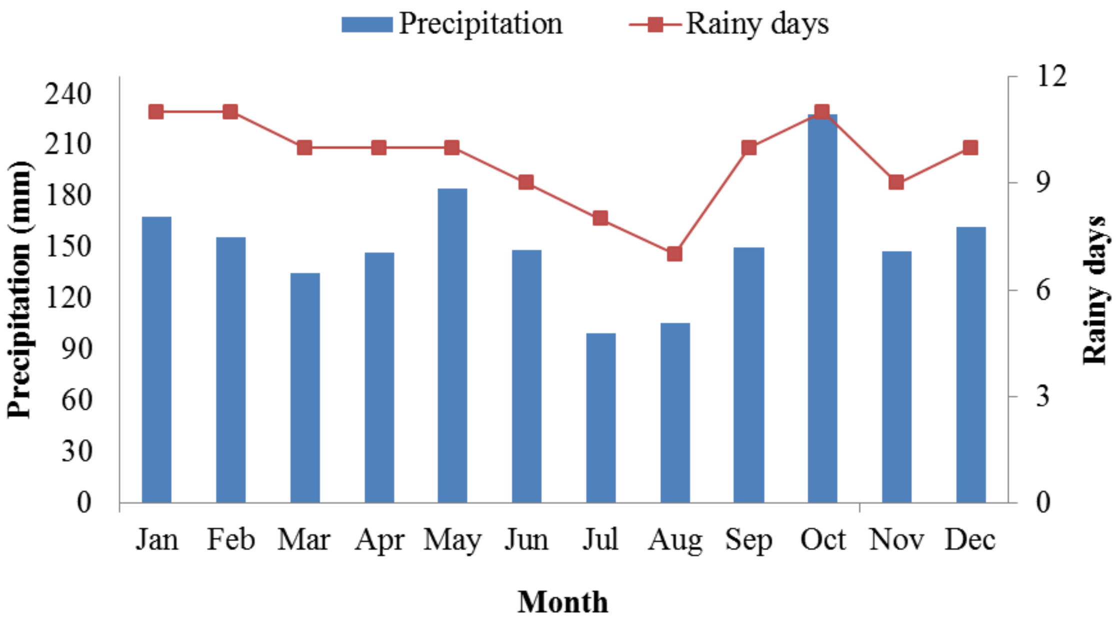
The behavior of monthly mean results in Figure 1, it appears that the current annual average temperature of the region during the study period was 21.4 ° C. The quarterly average warmest between November and January was 31.3 ° C and the coldest quarter May to July with 22.9 ° C. It is noted that summer temperatures are high, in the month of September the banks differently from other regions begin to rise leading to an early summer. Thus the region is classified as humid subtropical climate, with hot summers.



Source: IAPAR
Figure 1 - Average monthly maximum temperature, minimum and average air in SãoMiguel do Iguaçu - PR, in the period 1983 to 1997.

The historical average annual temperature range in the region of São Miguel do Iguaçu was 10.9 ° C. The smaller amplitude occurs monthly in June, with 10 ° C, and the largest in the month of August with 12 ° C. Regarding the monthly average temperature, it is noted that January is the month that has the highest average temperature, 25.7 ° C, since the average temperature of the coldest month is July, 17 ° C. Still evaluating the Figure 1 it is also noted that the mean maximum temperature was above 30 ° C between the months October to March, as the mean minimum in the months from May to September were below 16 ° C.

As can be seen in Figure 2, the sum of the average annual rainfall is 1831 mm in 117 rainy days a year. The region has good rainfall in the winter season records lower rates, combined with low T˚C which does not cause water deficit in the soil.

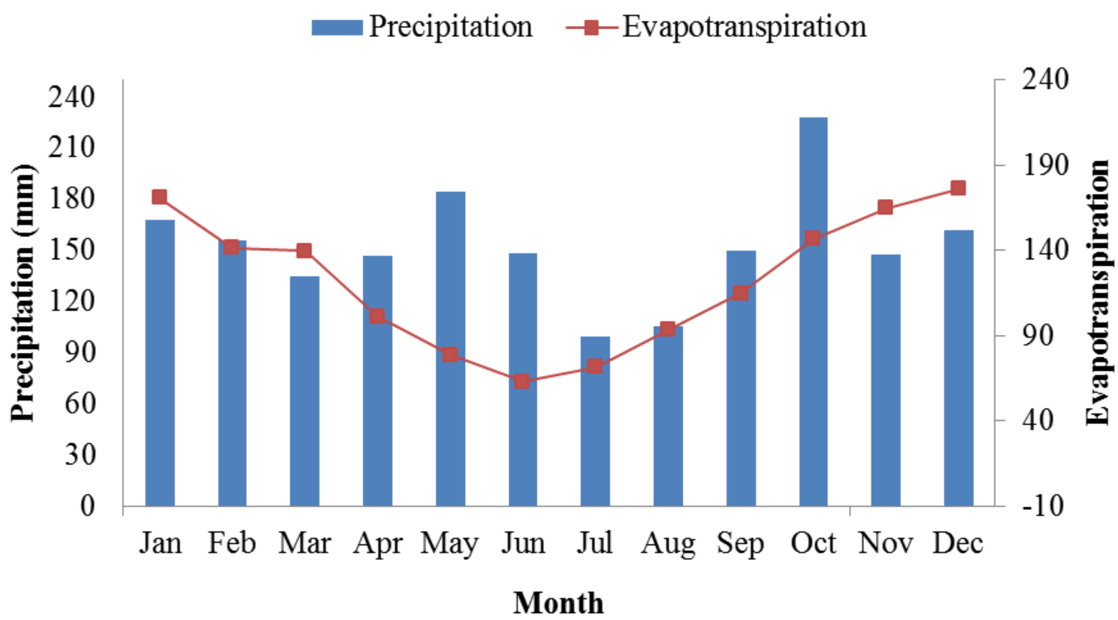


Source: IAPAR
Figure 2 - Average monthly rainfall and number of rainy days in São Miguel do Iguaçu -PR, in the period 1983 to 1997.

The sum of precipitation in each season is like having a small decrease in July and August. As can be seen in Figure 2, the average behavior and uniformity of distribution of the amount of rainfall in the first half is more uniform compared to the second. Similar to other cities of Paraná, in October and May, respectively, are the months with highest amount of rainfall, whereas the reverse occurs to July and August that are months of lower rainfall. October has an average record of 227.6 mm with 11 rainy days during the month, since the average rainfall was recorded in July to 99.7 mm with only seven days in the rainy months. It is noticed that we have 66% of months with less than 10 rainy days, the month that had the lowest number of rainy days in August was 7 days with rainfall of 105.4 mm behind only the month of July in the amount rainfall.

Whereas a water consumption of 7 mm per day, it would be necessary if a complete precipitation around 210 mm monthly to satisfy the demand of a culture regions subtropical climates. Observing Figure 2 it appears that only the month of October would total enough to meet this demand. It is not enough just to think of the total volume, but the uniformity of distribution over time.

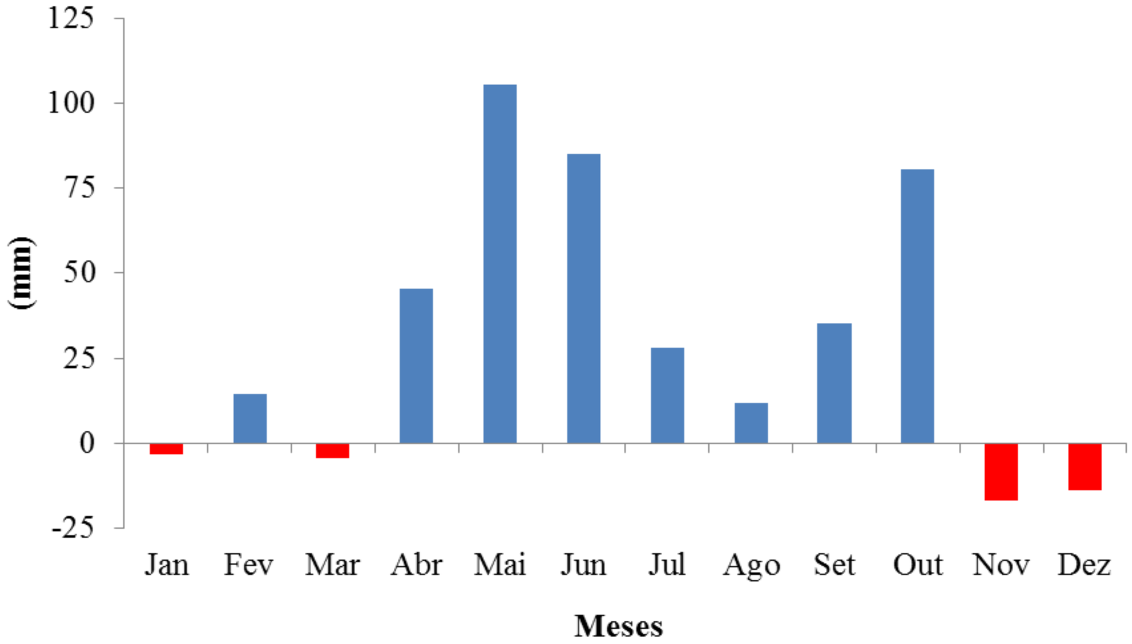
It can be seen in Figure 3 evapotranspiration, and average annual demand of the study period of 1362.2 mm. In Figure 3 we have the monthly averages of monthly average ET_0 estimated using equation (1). The highest values were recorded in ET_0 quarter (November to January) with precipitation remained stable with 477.6 mm and 39 rainy days in the quarter, but in contrast there was a considerable increase in temperature as can be seen in Figure 1, which showed averages of 31.3 ° C corresponding months. In this quarter there is a demand of 511.75 mm requiring replacement of 34.15 mm in the region. The greatest demand occurred in the month of December where ET_0 was greater than the rainfall of the month, then the evaporation exceeded precipitation. Except the month of March, February and August there is a surplus of water between precipitation and evapotranspiration.



Source: IAPAR

Figure 3 - Average monthly rainfall and evapotranspiration estimated by the method of Hargreaves and Samani in São Miguel do Iguaçu - PR, in the period 1983 to 1997.

In Figure 4 it is noted that has only four months that is greater than the ET_0 precipitation, or at most eight months other there is a marked difference in the precipitation exceeds evaporation. It is observed that the average of the last months of the year the need for replacement is more pronounced deficit of negative 31.98 in January compared to 3.17mm and 4.41 mm in March. As the region is characterized by low altitude is normal to the soybean (Glycine max) with cycles of early development in mid-September, this implies the second graph above at a great risk. In the region the T˚C in September are already in a strong growing enabling early sowing, generating great risks in the culture in their stages of flowering and grain formation due to the decrease of precipitation amount and regularity and dramatic increase in temperature causing glosses in yield.



Source: IAPAR

Figure 4 - Average monthly difference between precipitation and evapotranspiration estimated by the method of Hargreaves and Samani in São Miguel do Iguaçu - PR, in the period 1983 to 1997.

Considering the importance of water for crop development knowledge of climate variables or meteorological elements recorded in conventional or automatic stations allows the quantification of evapotranspiration, allowing to know the daily water demand of culture, as well as the monthly and annual region. ET_0 is therefore of fundamental significance for agricultural planning and decision-making about the choice of terrain, crop type, planting date, time of cultivation, harvesting, transport, storage or any other activity of a culture cycle . Another point to consider in relation to evapotranspiration is the design of systems and management of irrigation water, which requires the adoption of studies, evaluations and adjustments to its correct use (Mendonça and Dantas 2009).

This behavior of the distribution of rainfall for the city of São Miguel do Iguaçu has led to fluctuations in summer crops. In addition to the reduced availability of rainfall from November to February (period of highest growth and reproductive summer crops) the occurrence of dry spells associated with lower water availability in the soil during this period has been suggested as the cause of reductions in harvests. Despite the clear trend of increased crop production, resulting from technological advances in raw materials, genetic improvement and crop management each year seem to be more frequent and intense conditions of sudden and extreme weather conditions (Bergamaschi *et al*., 2006.)

According to Das (1995) the loss of water in the soil directly influences the development of crops, and then of paramount importance within the parameters agrometereology evapotranspiration data particularly in regions with water deficit requiring supplementation. The quantification of evapotranspiration, even in rain-fed agriculture is very important because it enables management strategies depending on the climatic conditions and soil water.

Conclusions

October is the month with highest rainfall over the study period. In four months of the year evapotranspiration was higher than the rainfall, creating a water deficit situation in the region requiring replacement. In the last two months of the year (November and December) this phenomenon is clearly marked by the need for regularity of the dramatic increase in precipitation and temperatures. Thus it appears that the region needs water supplementation at some time, especially at the end of the year during November and December where where usually it is cultivated plants not tolerant to high water deficit in the soil.

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