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Parameters of water consumption associated with the microclimate of an orchard of jaboticaba trees in southern Brazil

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ABSTRACT

This work aimed to quantify the evapotranspiration and to evaluate the microclimate of an orchard of jaboticaba trees [*Plinia peruviana* (Poir.) Govaerts]. Field studies were carried out in Porto Alegre, RS, in humid subtropical climate. The orchard was implanted in 2005, with plant spacing of 4.5m x 4.5m. Air temperature and relative humidity, photosynthetically active radiation (PAR), inside and outside the canopy, and soil moisture were monitored continuously. The evapotranspiration of the crop (ETc) was calculated by the decrease of the soil-water storage. The ETc/ETo ratio was determined by linear regression analysis, with ETo being the reference evapotranspiration. The relative humidity was higher inside than outside the canopy, with similar trend in air temperature. The interception efficiency of PAR increased from 80% in autumn-winter to 92% in spring-summer. ETc followed evaporative demand and leaf area, ranging from 0.3 to 3.2 mm day^{-1} in winter and from 0.2 to 5.0 mm day^{-1} in the summer. Most of the soil-water extraction occurred between 0 and 40 cm depth. The ETc/ETo ratio (assumed as Kc coefficient) was 0.95, ranging from 0.90 in winter to 1.06 in summer. Regression analyzes were effective in determining the ETc/ETm ratio, with better performance at high evaporative demand.

Introduction

Jaboticaba trees (*Plinia sp.*) comprise some native species of fruits to the center-south of Brazil, which belong to the family Myrtaceae. They are adapted to humid tropical and subtropical climates, which does not support prolonged droughts and strong frosts (Manica, 2000; Citadin et al, 2005).

According to Mattos (1983), apud Danner (2009), nine species of jaboticaba trees are known, of which only three are naturally distributed or cultivated in Brazil, while others are considered extinct. However, information in the literature is confused in terms of botanical identification of those species. In general, they are trees that reach up to 15 m in height, with a broadly branched trunk and an evergreen foliage.

Although having great potential for economic and ornamental exploitation, jaboticaba trees are still typical plants of small orchards. They still have little technical information on cropping systems, including water use and irrigation management. However, the fruits have great commercial acceptance, for either in natura consumption or for several industrial products. In addition, they have high levels of anthocyanins and flavonoids, making them as good source of antioxidant compounds, which characterize functional foods (Danner, 2009; Pereira, 2016; Altmann, 2017).

The microclimate is a determinant factor for plant phenology and sanity, as well as for numerous processes that define the productivity of crops. In jaboticaba trees, the main disease is rust, caused by the fungus *Puccinia psidii* Winter, which attacks young leaves, flowers and fruits (Soares et al., 2001). Its development is favored by high air humidity and mild temperatures (around 22°C), which are common in early spring. Therefore, the use of fungicides is recommended for this time, during the emission of vegetative flows, petal fall and fruit growth (Altmann, 2017). Low plant density and cleaning pruning may also favor aeration, solar radiation penetration into the canopy, and thus plant sanity (Donadio, 2000, quoted by Altmann, 2017).

Danner (2009) described that jaboticaba trees are sensitive to drought periods, due to the concentration of roots in superficial soil layers. In addition, when located outside the forest, they are also susceptible to the fall of plants in events of strong winds, which is another indicator of superficial rooting system. However, information on the water requirements of them is still scarce and inaccurate.

In a subtropical climate of southern Brazil, different water management regimes did not influence the reproductive and vegetative phenology of jaboticaba trees. However, daily irrigation provided higher yield, without altering the characteristics of fruits and the content of reserve substances in branches (Altmann, 2017).

The correct management of the water in farming systems becomes, increasingly, an indispensable conservation procedure, in order to rationalize its use, for increasing and stabilizing the crop production, besides reducing expenses with inputs. The daily crop evapotranspiration (ETc) and the crop coefficient (Kc) are fundamental parameters, for adopting a correct and precise water management, in special when using irrigation. In general, ETc and Kc are determined on field experiments, by quantifying each component of the soil water balance. Lysimeters are classical instruments for determining the components of the soil water balance (Pereira et al, 2013; Bergamaschi, 2017b). However, in the case of tall plants, such as jaboticaba trees, the use of lysimeters can be a difficult procedure. Nevertheless, even in this case, the soil water balance can be determined, and continuous measurement of soil moisture in the rooting zone may provide precise data, as described by Bergamaschi (2017b).

In this purpose, the main objective of this work was to quantify the evapotranspiration of a jaboticaba orchard, *Plinia peruviana* (Poir.) Govaerts, through the continuously monitoring of the soil-water storage, in order to obtain parameters that allow estimating its water consumption from meteorological data. As complement information, changes in the microclimate inside the plant canopy were evaluated, as comparing to the air conditions outside the orchard.

Material e methods

Conditions of the experimental site

The study was conducted from July 2015 to January 2017, in a commercial orchard of jaboticaba trees, located in the rural zone of Porto Alegre municipality, in Rio Grande do Sul State, southern of Brazil (latitude 30° 5' 45" S, longitude 51° 9' 14" W and altitude of 105m). The orchard was planted in 2005, in a 4.5m x 4.5m plant spacing, and was conducted without grafting and pruning management. During the experimental period, the crop canopy was about 3.5m tall, with open spaces of around 1m to 1.5m between plants.

The local soil was classified as haplic cambisoil, with inclusions of red-yellow argisoil (Hasenack et al., 2008). The experimental area used to be an old quarry, and the soil was reconstituted after that. It is located on the southeast slope of a hill, surrounded by sparse and tall vegetation.

The region has humid subtropical climate with warm summer, which belong to the specific variety Cfa, according to the climatic classification of Köeppen. According to Bergamaschi et al. (2003) the extreme means of global solar radiation oscillate between 8.6 MJ m^{-2} day^{-1}, in June, and 21.3 MJ m^{-2} day^{-1}, in December. The average annual rainfall is around 1,450mm, which is distributed throughout the year, and with a monthly average of around 120mm. January and February are the warmest months (average air temperature of 24.5°C), while June and July are the coldest months (average of 13.5°C). The air relative humidity has an inverse annual variation of the air temperature, but the averages are higher than 70% in every month. The wind speed is higher from September to December and lower from April to June. The total annual reference evapotranspiration (ETo - Penman method) is close to 1,200 mm. The monthly averages of ETo fluctuate from about 50mm, in June and July, to just over 150mm in

December and January. Therefore, monthly totals of ETo are lower than rainfall from April to September, but exceed the rainfall from November to March (Bergamaschi et al., 2003).

Microclimate of the orchard

In the summer of 2014/2015, an automatic weather station (AWS) was installed, just close to the orchard, in order to monitor the mesoclimate of the experimental site. It consisted of a Campbell® CR21X datalogger to which sensors of global solar radiation, air temperature and relative humidity, wind velocity, and rainfall were connected, all located at 2m above the ground.

The microclimate into the orchard was monitored, from July 2015 to July 2016, through an automatic system of measurement. The air temperature and relative humidity were measured through two psychrometers, composed by copper-constantan thermoelectric pairs. They were located inside the crown of a representative plant, at 1.50m above the ground, on opposite sides of the central branch. Photosynthetically active radiation (PAR) was measured through bars containing five amorphous silicon cells, all connected in parallel. They were installed at three levels above ground: at 0.50m (below the canopy), 1.50m (center of the canopy) and 3.7m (above the canopy). Each bar was calibrated against a Li-Cor® quantum sensor as standard. All sensors had two replicates and were connected to a Campbell® CR10X datalogger, which was programmed to perform readings every minute and store averages every 60min.

The photosynthetically active radiation incident on the plants (PAR_{inc}) was measured by the sensors (bars) located above the canopy, at 3.7m above the ground. The transmitted photosynthetically active radiation (PAR_t) was measured at two levels of the canopy: in the center, at 1.5m above the ground, and bellow the canopy, at 0.5m above the ground. From these parameters, the intercepted photosynthetically active radiation (PAR_{int}) was calculated for the upper half and for the entire canopy, by the following expression (Bergamaschi, 2017a):

$$PAR_{int} = PAR_{inc} - PAR_t$$

From data of intercepted radiation (PAR_{int}) and incident radiation on plants (PAR_{inc}), the interception efficiency of PAR (ε_i) was calculated for the upper half and for the entire canopy, by the following formula (Bergamaschi, 2017a):

$$\varepsilon_i = PAR_{int} / PAR_{inc}$$

The water stored in the soil, up to 60cm deep, was monitored by an automatic system composed of Water Content Reflectometer (WCR) sensors and a Campbell® CR10 datalogger, which was programmed to perform readings every minute and to calculate of averages every 60min.

In Excel/Microsoft® worksheets, changes in the microclimate of the canopy were evaluated, compared to the environment outside the orchard, which was monitored through the automatic weather station (AWS).

Parameters of water consumption

The soil-water storage was monitored from the winter of 2015 to the summer of 2017 by an automated monitoring system, composed of WCR sensors and a Campbell® CR10 datalogger. In this system, the volumetric moisture was measured every minute and its averages were stored every 60min. The sensors were installed within the plant rooting system, midway between the trunk and the crown periphery, at depths of 10cm, 30cm and 50cm, so representing the layers of 0 to 20cm, 20 to 40cm and 40 to 60cm, respectively. The data were computed in Campbell® PC200W software and transferred to Microsoft Excel® spreadsheets, in order to calculate totals and variations of water stored in the soil profile.

Crop evapotranspiration (ETc)

The crop evapotranspiration (ETc) was calculated on a daily basis (mm dia^{-1}) as equivalent to the decrease of water stored in the soil, on two consecutive days. Days with rainfall or shortly after each rainfall event were discarded, in order to avoid considering losses of water by surface runoff and by deep drainage in the soil profile. In order to apply this criterion, it was considered that soil moisture could not have a positive variation in any of the three measurement depths. Besides, a short period (in January 2016) was not considered in calculating the crop evapotranspiration, when the soil-water storage was less than 80% of field capacity, in order to reduce risks of water deficits in plants. Under these conditions, the loss of water from the soil profile was assumed (roughly) as the crop evapotranspiration (ETc).

Reference evapotranspiration (ETo)

Daily data of pluvial precipitation (rainfall) and of the elements necessary to calculate the reference evapotranspiration (ETo) were collected at the automatic weather station (AWS), close to the orchard. ETo was calculated by the Penman-Monteith method, parameterized according to Allen et al. (1998) by combining data of global solar radiation, air temperature and relative humidity, and wind speed.

Crop coefficient (Kc)

By means of linear regression analyses, daily values (mm day^{-1}) of crop evapotranspiration (ETc) and reference evapotranspiration (ETo) were compared. For each season and throughout all the year, the association degrees between ETc and ETo were evaluated through coefficients of determination (r^2) of each linear regressions. In the same way, and considering each adjusted function y = f (x), taking the linear parameter as equal to zero, the crop coefficient (Kc) remain equivalent to the angular parameter of each equation, which is:

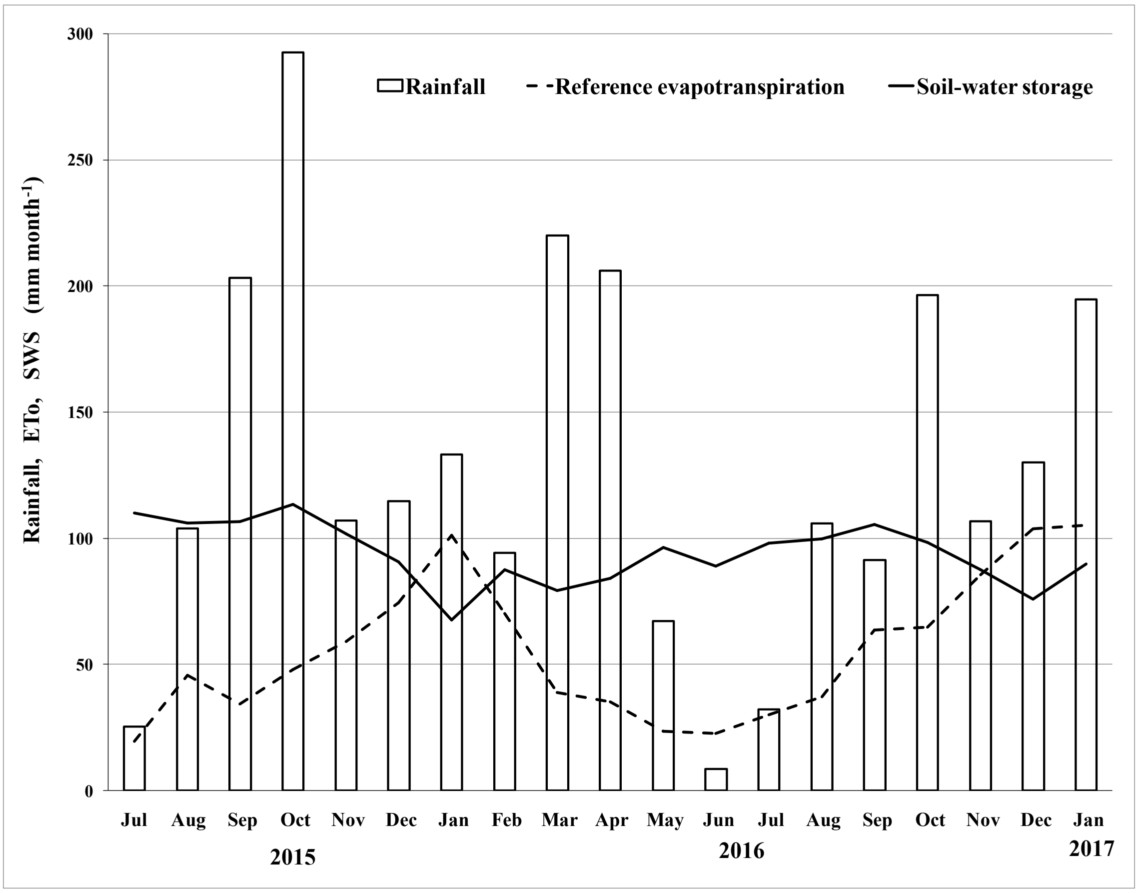
Kc = ETc / ETo

Results and discussion

The monthly rainfall totals exceeded those of reference evapotranspiration (ETo) in almost every month of the experimental period, except for July 2015, June and July 2016 (Figure 1). On the other hand, according to ETo values, the evaporative demand was low in those winter months. So that, the total soil-water storage remained high in the 0-60cm depth layer, despite the low rainfall in that period. In contrast, although having rainfall totals above ETo, there were some reductions in the soil-water storage in summer seasons, particularly in January and December 2016, which can be attributed to the high evaporative demand in short drought spells. Even so, there were no prolonged drought periods in the experimental area, considering the relationship between the monthly totals of rainfall and reference evapotranspiration, even in the warm seasons. Thus, the soil water storage remained high in autumn, winter and spring, reducing a little only in short periods of summer seasons, when there were few rainfall and high evaporative demand (Figure 1).

Monthly totals of ETo achieved around 100mm in summer seasons, but they remained bellow to 50mm over much of the fall-winter period (Figure 1). These values remain bellow to the climatic averages of the region, whose monthly values oscillate between 50mm and 150mm for winter and summer seasons, respectively (Bergamaschi et al., 2003). Among other causes, these differences between the ETo values obtained at the experimental site and the regional climatic averages can be attributed to the topographic condition (southeast slope of a hill) and to the presence of tall trees surrounding the area. In fact, in a complementary study, data collected in the AWS (next to the experiment) were compared to observations made at the Eighth District of Meteorology (8th DISME)

Figure 1. Monthly totals (mm) of rainfall and reference evapotranspiration (ETo, Penman-Monteith) and monthly averages of soil-water storage (SWS) from 0 to 60cm deep (mm) during the experimental period. Porto Alegre, Brazil, 2015 to 2017.



of the National Meteorological Institute, also located in Porto Alegre, about 5km far from the experiment (Afonso e Bergamaschi, 2016). It was verified that daily ETo estimated with data from the experimental area had mean reductions of 51% in winter and 36% in summer season, in comparison to daily ETo calculated with data from the 8th DISME. These differences in ETo are consistent with reductions in global solar radiation, 37% in winter and 33% in summer, and wind speed, 75% in winter and 52% in summer, from 8th DISME to the experimental site. These results show the importance of a detailed and specific weather monitoring in experimental areas, in particular for supporting detailed studies involving phenomena dependent on micrometeorological conditions (Afonso & Bergamaschi, 2016).

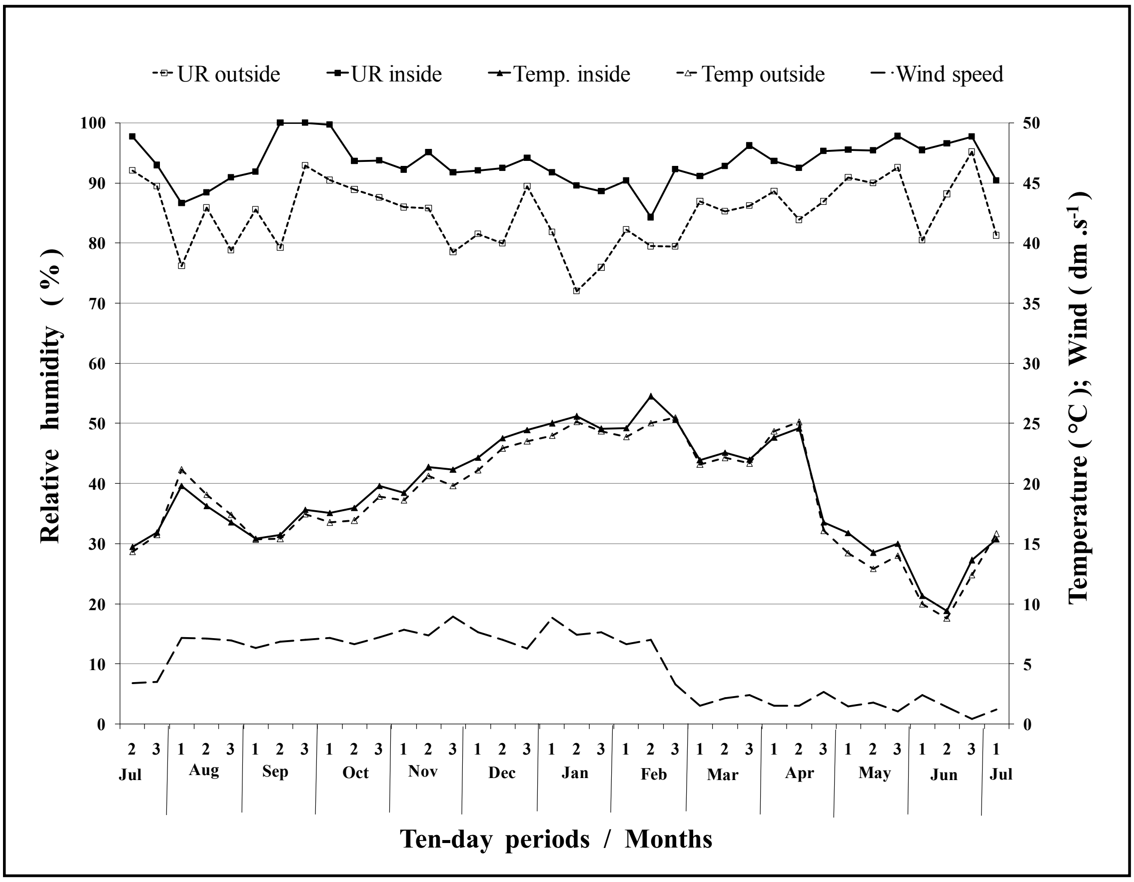
Microclimate in the orchard

The relative humidity of the air was always higher within the crown of the jaboticaba trees than in the air of the area surrounding the orchard. In turn, the air temperature was also higher inside than outside the plant crown, in most of the year (Figure 2). This means that the air inside the canopy maintained a higher concentration of water vapor than the external air, since the air relative humidity and temperature followed the same trend, unlike the normal relationship between these variables, which tend to vary in opposite directions. This indicates that the dense foliage of the plants made it difficult to diffuse heat and the water vapor from the transpiration to the air outside the canopy.

As the jaboticaba trees had no pruning management, over the 10 years prior to the experiment, the plants formed dense and "closed" crowns, enough to hinder the exchange of gases and heat with the external air. Soares et al. (2001) emphasized the susceptibility of jaboticaba trees to rust, a major disease that attacks young tissues, flowers and fruits, whose incidence is accentuated in an atmosphere with high humidity and mild temperatures (around 22 ° C). Figure 2 shows that this condition, favorable to rust, occurred from the spring and after, mainly inside the crown of the plants, where flowers and fruits develop, along the trunk and branches.

The wind data (Figure 2) show that the experimental period followed the regional trend, which is of higher average velocity in the spring-summer period than in the autumn and winter seasons (Bergamaschi et al., 2003).

Figure 2. Air temperature and relative humidity inside and outside the plant crown, and wind speed in outside air, close to the orchard. Porto Alegre, Brazil, 2015 to 2016.



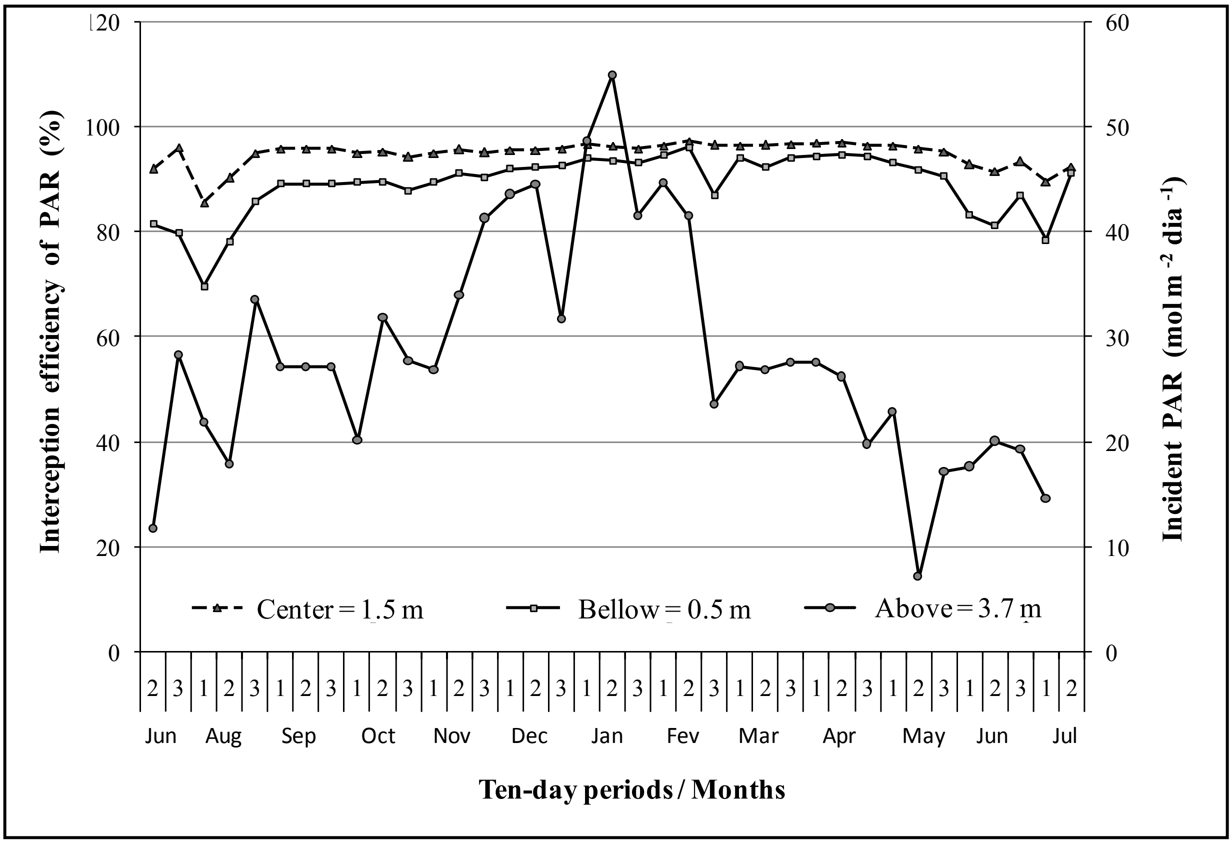
Increases in wind speed, during the hot season, should be important for favoring aeration within the crown of plants. However, increases of foliage density from spring and after, due to new shoots and increasing leaf area, tend to counteract and reduce, even more, the exchange of gases and heat with the external air. According to Donadio (2000), apud Altmann (2017), the vegetative growth of jaboticaba trees is intense from the end of winter, a period that precedes the main flowering season, after the occurrence of rhytidoma (detachment of cortex from trunk and branches). This process occurred in the experimental area, because the main and intense budding took place from the end of winter and to the beginning of spring season. On the contrary, intense fall of leaves occurred from April to July 2015 (autumn and beginning of winter), which implies in reduction of the foliage density (Altmann, 2017).

The mean interception efficiency of photosynthetically active radiation (PAR) by the crown of the plants was 92% in the spring-summer period and 80% in the autumn-winter period (Figure 3). Therefore, the high density of crowns, throughout the year, also affected the distribution of solar radiation in the canopy of the jaboticaba trees. On the other hand, the increase in interception efficiency of PAR during the period of higher solar radiation (spring-summer) indicates a seasonal increase in leaf area, due to the emission of new leaves and shoots during the hot season, as was observed by Altmann (2017). This means that, although with higher incidence of solar radiation, the canopy intercepted a higher percentage of PAR in late spring and summer than in the rest of the year due to the greater leaf area.

Figure 4 shows the diurnal variation of the amount of incident PAR over the plants, in the middle of the crown and at the base of the canopy, throughout a sunny day. For all the day, there was a greater flux of solar radiation (transmitted PAR) at the base of the canopy than in the middle of the crown. This indicates that the flux of incident PAR at the base of the canopy was in a great part reflected along the open spaces between plants, since it was higher than the PAR flux transmitted by the upper half of the crown, i.e. from the top to the center of the canopy.

This set of results, related of microclimate at level of plants, are in accordance to observations of Donadio (2000), apud Altmann (2017), regarding to the management of jaboticaba trees. According to him, low density of plants and cleaning pruning tend to favor the aeration (gas exchange) and the penetration of solar radiation into the

Figure 3. Incident photosynthetically active radiation (PAR) above the canopy and interception efficiency of PAR, based on measurements at the center and bellow the crown of jaboticaba trees. Porto Alegre, Brazil, 2015 to 2016.



canopy, providing a better sanity of plants and, therefore, better conditions for the phenological development, production and quality of the fruits.

Parameters of water consumption

With the soil moisture data, provided by the WCR sensors, it was possible to determine the amount of water stored in the 0-40cm and 0-60cm soil layers, from the winter of 2015 to the summer of 2017. The soil-water storage remained high in autumn, winter and spring seasons, but was reduced during the hot season, in short periods of low rainfall and high evaporative demand (Figure 5). On the other hand, there were short events of increase of the soil-water storage, just after the occurrence of intense rains.

In periods without rainfall, the decreases of soil-water storage allowed quantifying the crop evapotranspiration (ETc), at a daily level. Data of ETc were related through linear regression analysis to the reference evapotranspiration (ETo), in order to determine the ETc/ETo ratio (here assumed as the Kc coefficient), for each season (Figure 6) as well as for the whole analyzed period (Figure 7). In winter season, ETc ranged from 0.28 to 3.18 mm day^{-1}, while in summer it varied from 0.15 to 4.97 mm day^{-1}. Therefore, the orchard reached higher water consumption in summer than in winter, which can be attributed to the seasonal variation of the evaporative demand of the atmosphere. In addition, intra-seasonal variability was lower in winter than in summer season (Figure 6), which can be attributed to the variation pattern of incident solar radiation at each season, since it is considered the main determinant of atmospheric evaporative demand (Bergamaschi, 2017b).

During the winter season, the evapotranspiration of the orchard had maximum values around 3.2 mm dia^{-1}, which are in the order of magnitude for water consumption by winter crops in subtropical conditions of Brazil (Monteiro, 2009). During the summer, maximum values of ETc (around 5.0 mm dia^{-1}) were lower than the water consumption of most annual field crops, in the hot season. However, those values are equivalent to the evapotranspiration of vineyards, also determined in the Brazilian subtropical region by Conceição & Maia (2001), apud Monteiro (2009).

According to the regression analyses, the ETc = f * (ETo) function provided an average ETc/ETo ratio of 0.95 (here assumed as Kc coefficient) for the entire experimental period (Figure 7). Such a mean value for the ETc/ETo ratio is lower than most of Kc coefficients for farm crops at mid-cycle, but, it is equivalent to typical Kc values for open

Figure 4. Photosynthetically active radiation (PAR) measured at above (3.7m), at the center (1.5m) and at below (0.5m) to the crown of jabuticaba trees, throughout the day of July 28, 2015. Porto Alegre, Brazil.

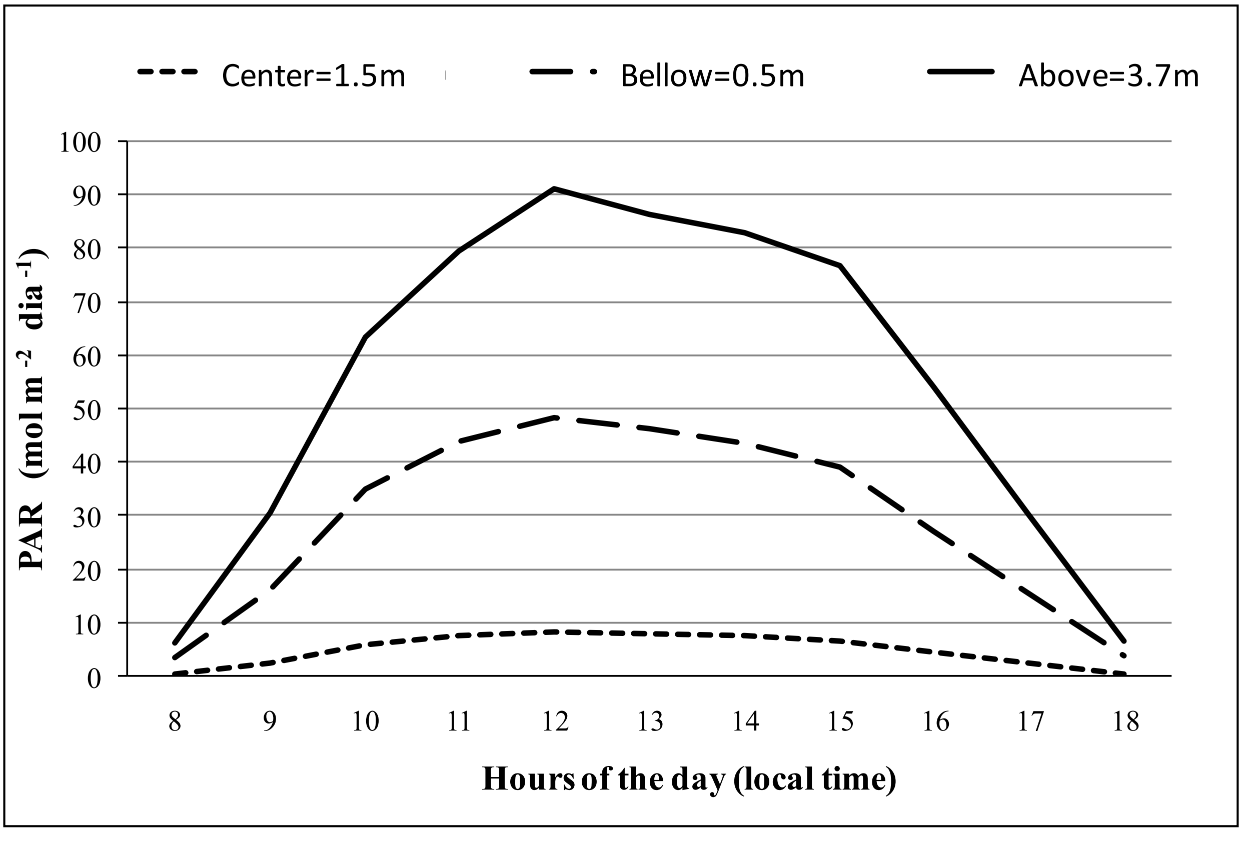
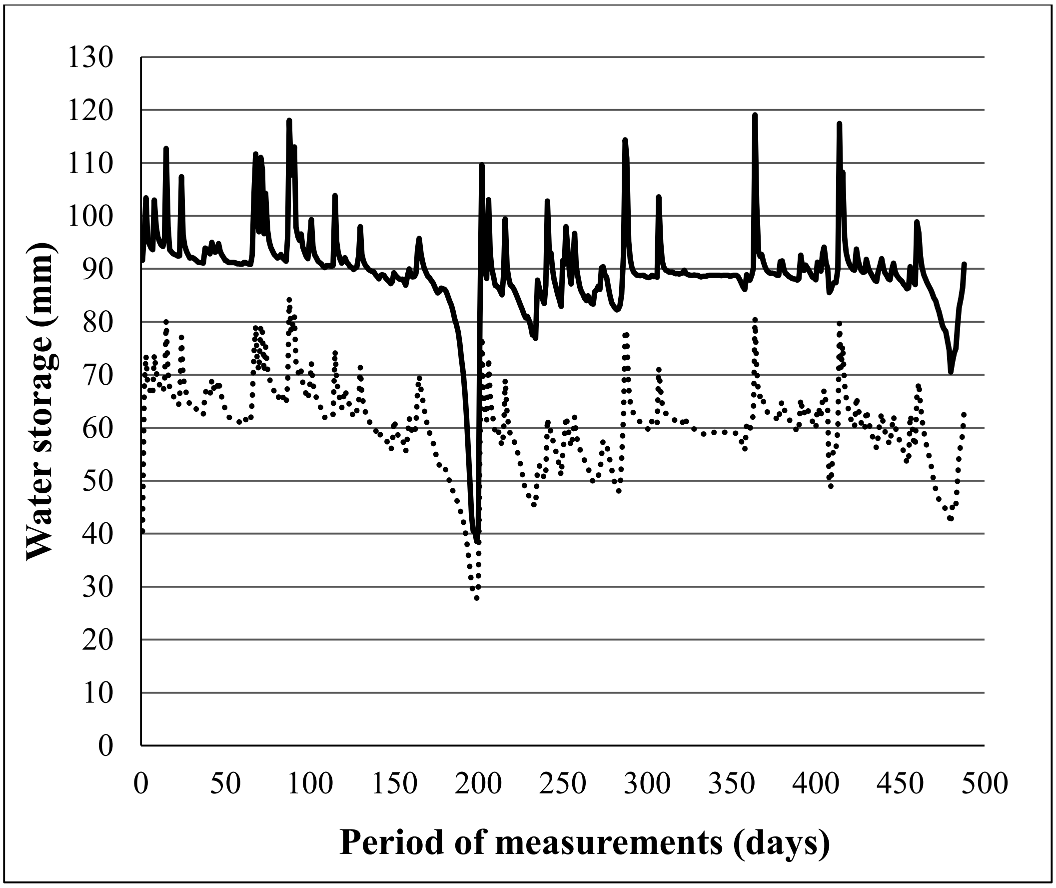


Figure 5. Soil-water storage (mm) in the 0-40cm (dotted line) and 0-60cm (solid line) depth layers, during the experimental period. Porto Alegre, Brazil, 2015 to 2017.



orchards, as referred by Allen et al. (1998) and Bergamaschi (2017b).

The ETc/ETo ratio was 0.90 (with r^2 = 0.35) for winter season, when the jaboticaba trees have reduced the leaf area index, as referred by Altmann (2017), so affecting the evapotranspiration. In summer, the ETc/ETo ratio was 1.06 (with r^2 = 0.81), when the leaf area of plants and the evaporative demand were higher than in winter season. The seasonal variation of the ETc/ETo ratio is consistent with the trend of the observed interception efficiency of PAR (ε_i). However, the reference evapotranspiration (i.e., atmospheric evaporative demand) had a much more pronounced annual oscillation (Figure 1) than the interception efficiency of PAR (Figure 3) and, so, than the leaf area of jaboticaba trees. Therefore, other factors besides of the leaf area must have influenced the seasonal variation of the crop evapotranspiration. For example, it should be considered also that most of the foliage was younger in summer than in winter season, so influencing on the physiological activity of leaves, including the flux density of transpiration.

The fractioning of the soil-water depletion revealed that, in the average of the entire experimental period, the soil-water extracted from the 0-40cm depth layer corresponded to 67% of the total crop evapotranspiration. This result confirms that the rooting system of the jaboticaba trees was relatively superficial, in the soil profile, as was described by Danner (2009). This author attributed this characteristic to the origin of this specie, which comes from lower strata of forest ecosystems, where the plants develop under the protection of tall trees. It also justifies the sensitivity of jaboticaba trees to water deficits and also their susceptibility to falling by strong winds, when they are located in the open sky.

The methodology and procedures of this study, for determining the crop the evapotranspiration (ETc) and the Kc coefficient at daily level and at different seasons of the year, showed to be adequate and reliable. The use of electronic sensors coupled to automated data acquisition systems, when properly implemented and operated, provides a precise quantification of changes of the soil-water storage. However, this precision is possible when errors and inaccuracies due to other water losses from the soil profile (in exception of evapotranspiration) such as superficial runoff, deep drainage, or capillary ascension are negligible or measured, as described by Bergamaschi (2017b).

The regression analyzes between ETc and ETo (Figure

Figure 6. Relationships between crop evapotranspiration (ETc) and reference evapotranspiration (ETo) in a jaboticaba orchard in winter (A), spring (B), summer (C), and autumn (D), with trend lines (solid) and 1:1 lines (dashed). Porto Alegre, Brazil, 2015 to 2017.

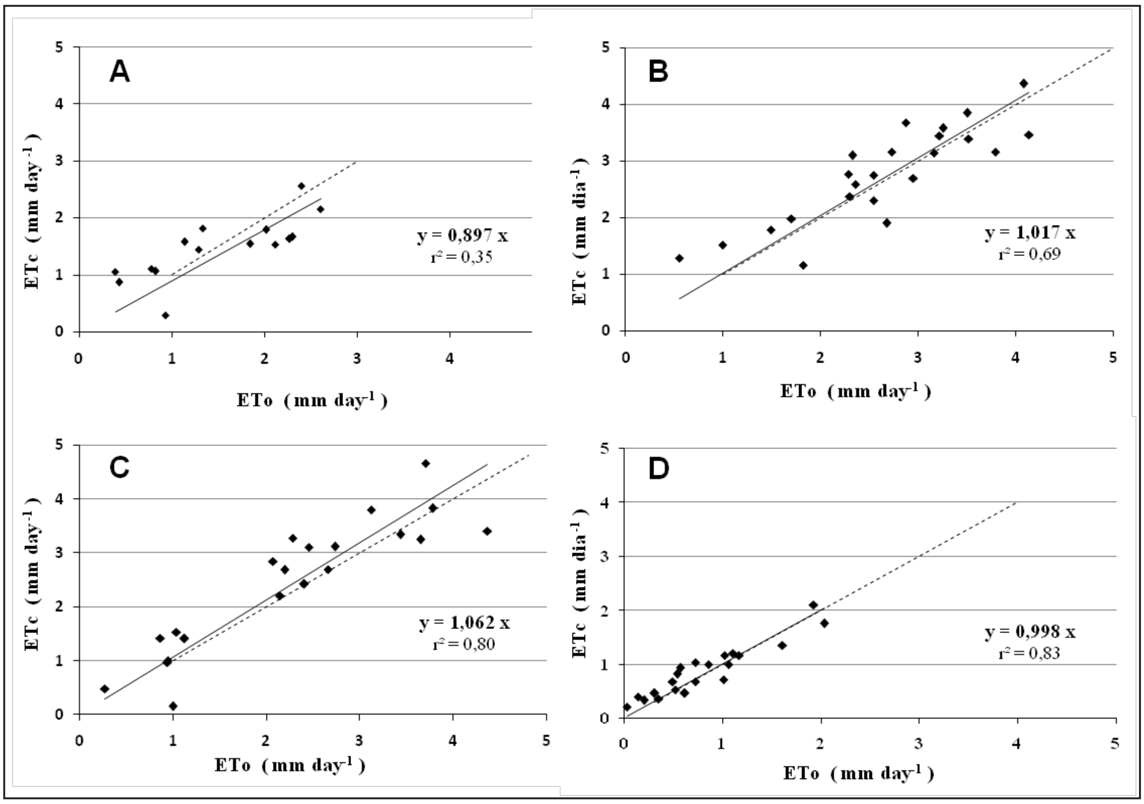
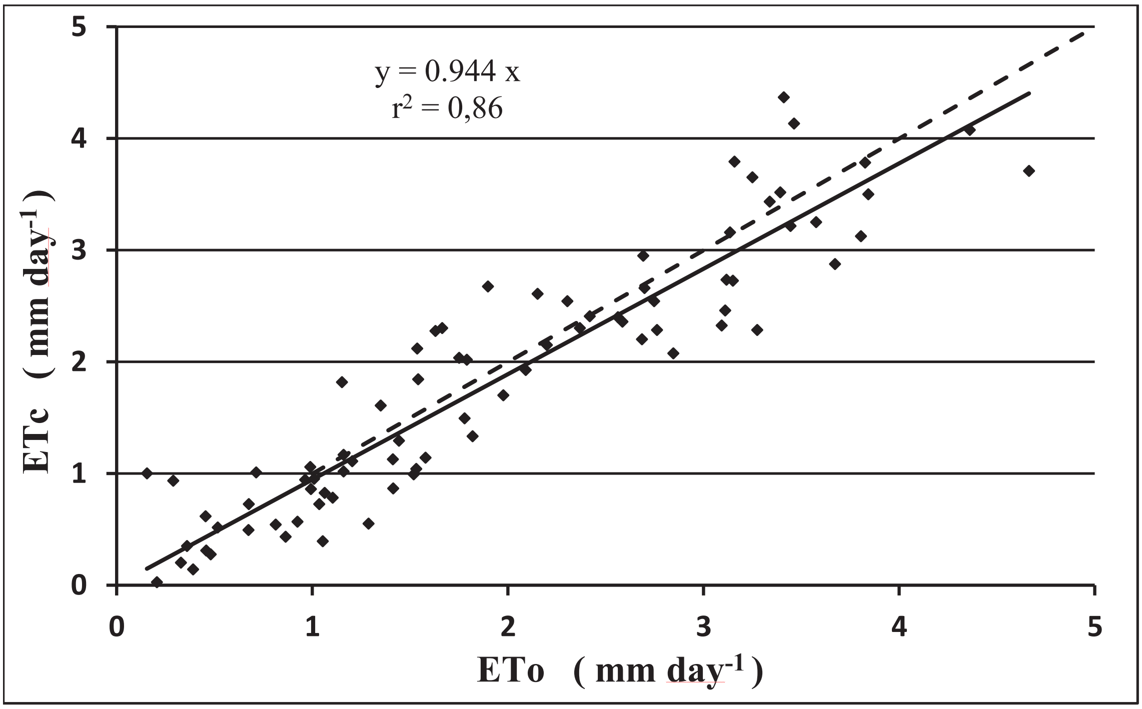


Figure 7. Relationship between crop evapotranspiration (ETc) and reference evapotranspiration (ETo) in all year round for a jaboticaba orchard, with the linear trend (solid line) and the 1:1 relation (dashed line). Porto Alegre, Brazil, 2015 to 2017.



6) showed that the field procedures, for determining ETc, were less accurate for winter season than for the rest of the year. Besides of the narrow variation range of ETc and ETo in winter, because of the low evaporative demand, the low r^2 coefficient suggests some errors in quantifying the ETc by the soil-water balance, due to possible water losses from the volume of soil control, even because the soil-water storage remained high throughout the cold season. Otherwise, the high r^2 coefficients obtained in analyzing data from the warm seasons revealed that the methodology used in this study showed to be precise and reliable for determining ETc of field crops (even with tall trees), when using data from environments of high atmospheric evaporative demand, with a wide variation range of ETc and ETo.

Conclusions

In jaboticaba trees the air relative humidity is ever higher inside the plant crown than in the external air. A similar tendency occurs with the air temperature, for most of the year.

The interception efficiency of photosynthetically active radiation (PAR) by jaboticaba trees is lower in the autumn-winter period than in the spring-summer period, due to a partial senescence of leaves.

Jaboticaba orchards present annual variations in the crop evapotranspiration, following oscillations of atmospheric evaporative demand and of leaf area.

Most of the water extracted from the soil by jaboticaba trees occurs at depths of up to 40cm.

Linear regression analyses are effective in determining the crop coefficient (Kc) by the ETc/ETo ratio, whose accuracy increases in conditions of high atmospheric evaporative demand.

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Parâmetros do consumo de água associado ao microclima de um pomar de jabuticabeiras no sul do Brasil

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RESUMO

Este trabalho objetivou quantificar a evapotranspiração e avaliar o microclima de um pomar de jabuticabeiras [*Plinia peruviana* (Poir.) Govaerts]. Estudos de campo foram realizados em Porto Alegre, RS, em clima subtropical úmido. O pomar foi implantado em 2005, com espaçamento de 4,5m x 4,5m. Temperatura e umidade relativa do ar, radiação fotossinteticamente ativa (RFA), dentro e fora do dossel, e umidade do solo foram monitoradas continuamente. Calculou-se a evapotranspiração da cultura (ETc) pela diminuição da água armazenada no solo. Determinou-se a razão ETc/ETo por análise de regressão linear, sendo ETo a evapotranspiração de referência. Maior umidade relativa do ar ocorreu dentro do dossel, com tendência similar na temperatura. A eficiência de interceptação de RFA aumentou de 80% no outono-inverno para 92% na primavera-verão. ETc seguiu a demanda evaporativa e a área foliar, variando de 0,3 a 3,2 mm dia^{-1} no inverno e de 0,2 a 5,0 mm dia^{-1} no verão. Maior extração de água do solo ocorreu entre 0 e 40 cm de profundidade. A razão média ETc/ETo (assumida como coeficiente Kc) foi 0,95, oscilando entre 0,90 no inverno e 1,06 no verão. Análises de regressão foram eficazes em determinar a razão ETc/ETm, com melhor desempenho em alta demanda evaporativa.

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