ETc AND Kc DETERMINATION FOR MARANDU PALISADEGRASS COVER OVERSEEDED WITH DIFFERENT WINTER FORAGE SETS

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ABSTRACT: Cattle herding has significant relevance for the Brazilian economy, given the large global demand for meat and dairy from Brazil. Thus, a need has arisen for studies aimed at increasing production without expanding plantation area and which bypass seasonal effects. Irrigation and overseeding with winter forage crops are ways of intensifying productivity in livestock systems. To ensure adequate irrigation management, it is necessary to understand the crop's evapotranspiration (ET_c) and the crop's coefficient (K_c). Therefore, the goal of this study was to determine ET_c and K_c in an overseeded Marandu palisadegrass with two sets of winter forage cover, over their growth cycles, using the standard weighing lysimeter method. It was observed that the Marandu palisadegrass + cereal rye + ryegrass set obtained a larger cumulative ET_c when compared to the Marandu palisadegrass + black oat + ryegrass set, which indicates a difference in the water consumption between distinct winter forages and, consequently, causes different irrigation layers between the sets.
KEYWORDS: Livestock Systems; Weighing Lysimeter; Water Consumption

DETERMIAÇÃO DE ETc e Kc PARA DOSSEIS DE CAPIM MARANDU SOBRESSEMADOS COM DIFERENTES CONJUNTOS DE FORRAGEIRAS DE INVERNO

RESUMO: A pecuária tem significativa relevância na economia brasileira devido à grande demanda mundial de carne e leite provenientes do Brasil. Assim, surge a necessidade de estudos que visam aumentar a produção sem expandir área de plantio e que contornem efeitos

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de estacionalidade, sendo a irrigação e a sobresssemeadura com forrageiras de inverno, formas de intensificar a produtividade de sistemas agropecuários. Para um manejo da irrigação adequado é necessário o conhecimento da evapotranspiração da cultura (ETc) e coeficiente de cultura (Kc). Portanto, o objetivo deste trabalho foi determinar a ETc e o Kc, em um dossel de capim Marandu sobressemeado com dois conjuntos de duas forrageiras de inverno, ao longo de seus ciclos de crescimento, utilizando o método padrão da lisimetria de pesagem. Foi observado que o conjunto capim Marandu + centeio + azevém obteve uma maior ETc acumulada em relação ao conjunto capim Marandu + aveia preta + azevém, o que evidencia uma diferença de consumo hídrico entre distintas forrageiras de inverno e, consequentemente, ocasionando diferentes lâminas de irrigação entre os conjuntos.
KEYWORDS: Sistemas agropecuários**,** Lisimetria de Pesagem, Consumo Hídrico.

INTRODUCTION

Brazil is the second largest producer, and largest exporter of meat worldwide (USDA, 2018). The vast majority of meat and milk herds use pastures for feeding. Among the diverse forage types used for pastures, the most commonly used in Brazil is the Marandu palisadegrass (*Urochloa brizantha* cv. Marandu) (BISCOLA; PEREIRA; COSTA, 2013).

Technological advances and techniques aimed at increasing productivity and lowering the seasonal effect are present in national cattle herding, among which are irrigation and overseeding. Irrigation has been expanding in the agricultural sector, due to the increase in biomass production. Some studies cite that the grazing interval is greatest in non-irrigated pastures, varying from 185 to 155 days in rainfed areas, and from 70 to 66 days in irrigated areas (DANTAS *et al*., 2016).

Overseeding consists of introducing winter forage into a pre-existing forage cover, with the intent of increasing production in areas prone to seasonality. Interaction between tropical grass and winter forage as black oat and ryegrass are commonly studied in the central-south of Brazil (GERDES, 2005; SANCHES *et al*., 2019). Another usable species is the cereal rye, which stands out for its vigorous initial growth, rusticity and resistance to cold, drought and soil acidity (BAIER, 1994). The use of black oat, ryegrass and cereal rye may be interest for overseeding.

One of the premises of irrigation management is applying the layer of water necessary for the crop to express its development, without water restrictions. For this, it is necessary to estimate crop evapotranspiration (ET_c) and the crop coefficient (K_c) (MINUZZI *et al*.,2014). The method that is considered the standard for estimating ET_c is weight lysimeter, a system consisting of measuring the variation in weight of a block of soil by load cells, whose data is converted into estimations of the entry and exit of water. Its primary advantages are short measurement intervals, automation, and a wide weight variation data storage capacity, due to the use of a data acquisition system (SCHMIDT *et al*., 2013).

Given the scarcity of studies on water consumption in winter forages overseeded with tropical species, the goal of this work was to determine ET_c and K_c in a cover of Marandu palisagrass overseeded with two sets of two winter forages, over the course of their growth cycles.

MATERIAL AND METHODS

The experiment was conducted between May and September of 2018 in an experimental area of the Escola Superior de Agricultura "Luiz de Queiroz" (ESALQ/USP), in the city of Piracicaba/SP (22º14'02" S, 47º37'23" O). The experimental area was divided in two parcels of 12 x 12 meters, with Marandu palisadegrass (*Urochloa brizantha* cv. Marandu) established in the year 2016. The winter crops used were black oat (*Avena strigosa* cv. IAPAR 61), ryegrass (*Lolium multiflorum* cv. BRS Ponteio), and cereal rye (*Secale cereale* cv IPR 89). The overseeding was performed by tossing the seed on the Marandu palisadegrass cover, into which an experimental parcel was designated for studies on overseeding with black oat + ryegrass, and another plot with cereal rye and ryegrass. The sowing rates of winter crops were 100 kg ha^{-1} for black oat and cereal rye and 50 kg ha^{-1} for ryegrass. 3 productive cycles were studied during the period, with a duration of 42 days before harvest (between 21/05/2018 and 24/09/2018). The irrigation system utilized in the experiment was a standard sprinkler, with spacing of 12 x 12 m and a flow rate of 1.64 x 10^{-3} m^3 s^{-1}.

At the center of each plot was a weighing lysimeter for determining the ET_c of the forage cover. Each lysimeter was inserted into the soil and leveled. The lysimeters were composed of a circular, rigid PVC box, with a diameter of 1.22 m, height of 0.58 m and a volume of 500 liters, with brick walls 0.12 m thick for withstanding the surrounding soil. Both lysimeters also possess charging systems, weighing systems and a water collection and drainage system. The data received in millivolts (mV) were calibrated to express the weight in kilograms according to Sanches (2017).

Crop evapotranspiration (ET_c) using the lysimeters was obtained by balancing the entry and exit of water through the lysimeters (equation 1).

$$ETc = \Delta sto + P + I - \Delta dre \quad (1)$$

In which:

ETc – Crop evapotranspiration (mm day^{-1});

Δ_{sto} – storage variation (mm day^{-1}); and

P- Rain precipitation (mm day^{-1});

I – Irrigation (mm dia^{-1});

Δ_{dre} – Dreinage variation (mm dia^{-1}).

Some criteria were adopted following the methodology proposed by Souza (2017), with the goal of avoiding overestimated ET_C values, as the exclusion of data due the wind direction that could cause advection, couting data only during the photoperiod and excluding ETc values greater than 0.25 mm at 15 minutes intervals.

In addition to determining the ET_C, lysimeter data were used for irrigation management, the liquid irrigation and gross irrigation requiriment were determined in the equation 2 and 3:

$$Li = \frac{(W_{fc} - W_r)}{Z_{lis} \; A_{lis}} z \quad (2)$$

In which:

Li – water irrigation requirement (mm);

Wfc – weighing in the field capacity (kg);

Wr – weighing in the real humidity (kg);

Zlis – Lysimeter Depth (Zlis = 60 cm);

Alis – Lysimeter surface area (m^2); and

Z – Effective root depth (Z = 90 cm).

$$Lg = \frac{Li}{Ie} \quad (3)$$

In which:

Lg – Gross irrigation requirement (mm);

Ie – Irrigation efficiency (Ie for standard sprinkler is 0,85)

The reference evapotranspiration (ETo) was calculated by using data obtained from the automated meteorology station, situation near the experimental area, by means of the Penman-Monteith (equation 2), proposed by the FAO 56 methodology (ALLEN *et al.*, 1998).

$$ETo = \frac{0{,}408\ s\ (Rb - G) + \frac{\gamma\ Cn\ U_2\ (es - ea)}{T + 273}}{s + \gamma\ (1 + Cd\ U2)} \qquad (2)$$

In which:

ETo – reference evapotranspiration ($mm.day^{-1}$);

Rb – net radiation at the crop surface ($MJ.m^{-2}.day^{-1}$);

G – soil heat flux density ($MJ.m^{-2}.day^{-1}$);

γ = psychometric constant (0,063 $kPa.^{o}C^{-1}$);

U_2 – wind speed at 2 m high ($m.s^{-1}$);

es – saturation vapor pressure (kPa);

ea – actual vapor pressure (kPa);

T – mean daily air temperature (ºC);

s – slope vapor pressure curve based on air temperature ($kPa.^{o}C^{-1}$) equation 3:

$$s = \frac{4098\ es}{(T + 237{,}3)^2} \qquad (3)$$

The crop coefficient (Kc) was calculated on a 4-day interval, using the ratio of crop evapotranspiration to the reference evapotranspiration.

RESULTS AND DISCUSSION

Climate data for the experiment period can be seen in Figure 1. During the experiment, the total rain precipitation was 166.6 mm. The months of June and July registered 8.9 mm and 2.5 mm of rain respectively, values lower than the historical average for these months – 44.0 mm for June and 29.0 mm for July. The rainfall in August was 105.7 mm, higher than the historical average for this period (29.8 mm), and September registered 54,0 mm, near the average for this month (61.9 mm). Due to the irregularity of the rain precipitation, it was necessary to supplement the water supply in the dry period during the 3 cycles. MBOR forage set was irrigated 344.09 mm, and the MCR was irrigated 280.34 mm.

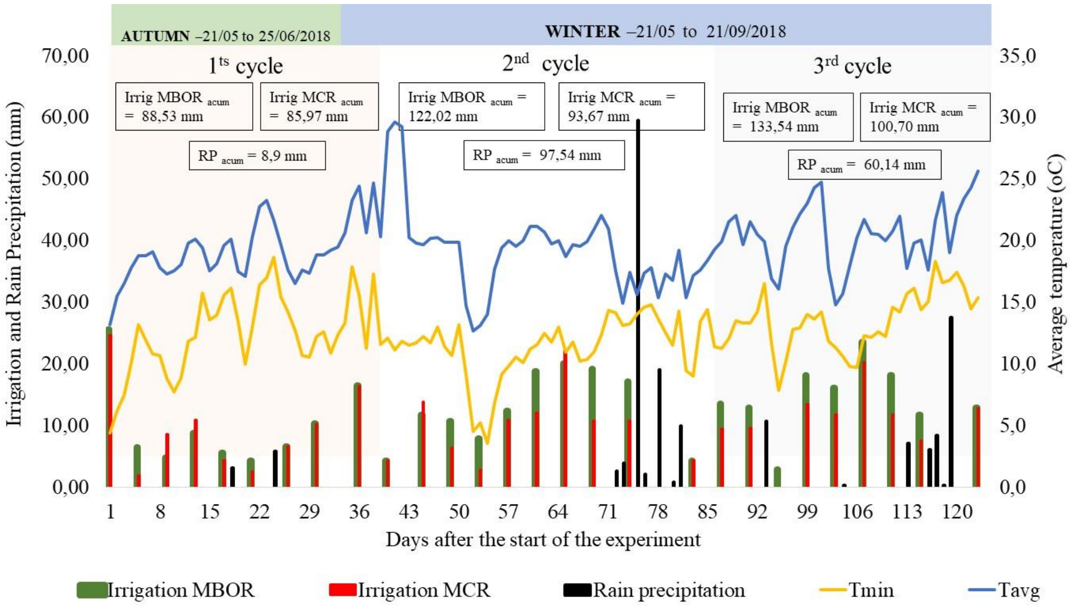

Figure 1. Precipitation values (mm), relative humidity (RHmed,%), minimum temperature (Tmin, oC) and average temperature (Tmed, ºC) during the experimental period, Piracicaba/SP, 2018. Legend: Irrig MBOR $_{acum}$= Irrigation accumulated for Marandu palisadegrass overseeded with black oat + ryegrass, Irrig MCR $_{acum}$= Irrigation accumulated for Marandu palisadegrass overseeded with cereal rye + ryegrass, RP $_{acum}$= Total rain precipitation accumulated.

The daily ET_C average, as well as the ET_C and ET_O accumulated in each cycle, can be seen in Figure 2. In comparing the forage covers, the Marandu palisagrass + cereal rye + ryegrass cover presented the highest consumption of water, with a cumulative ET_C of 300.28 mm, while the Marandu palisagrass overseeded with black oat + ryegrass consumed 279.87 mm, over the fall/winter period.

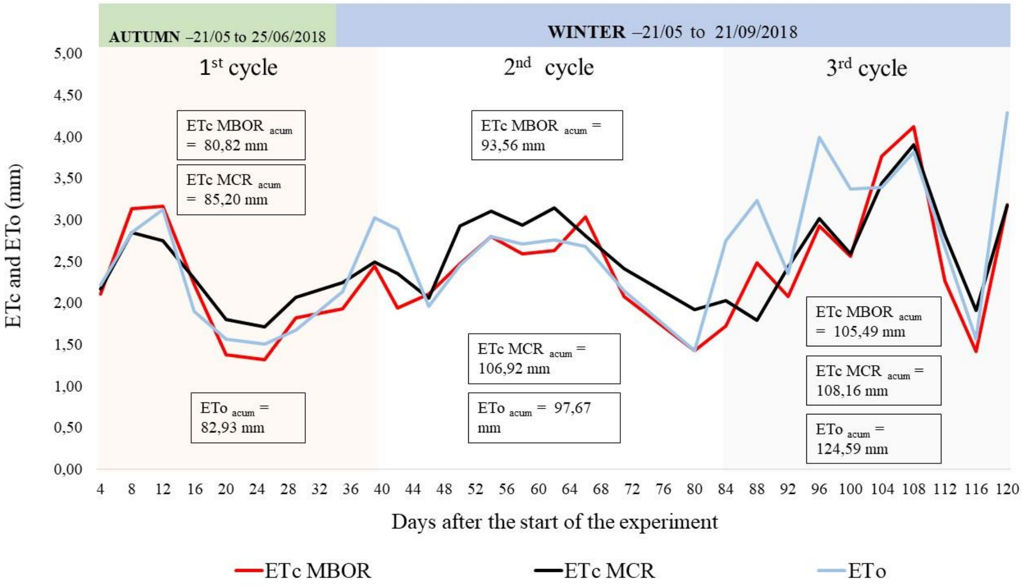

Figure 2. Average crop evapotranspiration (ET_C) values and reference evapotranspiration (ET_O) in mm day^{-1} for Marandu palisagrass overseeded with different winter forage sets by cycle, Piracicaba/SP, 2018. Legend: ETc $MBOR_{acum}$ = ETc accumulated estimate for Marandu palisadegrass overseeded with black oat + ryegrass, ETc MCR_{acum} = ETc accumulated estimate for Marandu palisadegrass overseeded with cereal rye + ryegrass and ETo_{acum} = ETo accumulated in the cycle.

The values observed are close to other studies on water consumption of winter forage crops. Qi and Helmers (2010) obtained a daily average ET_C by weighing lysimetry, in a cereal rye cultivation of 2.40 mm day^{-1}, in Iowa (USA) – a value similar to that encountered in the current study (2.54 mm day^{-1}). Saldias *et al*. (2018) estimated the evapotranspiration of black oat and wheat cultures in the central region of Chile, through water balance with a neutron probe. The authors obtained a cumulative ET_C of 300 mm for each 4-month cycle, averaging the tree years of the experiment, a value similar to that of this study.

The values of ETc were near to ETo, during the first two cycles, in both two forages sets, but during the beginning and in the middle of the third cycle, it was possible to observe a considerable difference between ETc and ETo. One possible explanation for this event would be the decoupling between the forage sets and the atmosphere, when ETo is high and the ETc does not follow this elevation due to the plant stomatal resistance mechanism (MARIN *et al*., 2016).

The K_C values were also greater for the Marandu palisadegrass overseeded with cereal rye + ryegrass, with values that varied between 0.55 and 1.34, in relation to the black oat + ryegrass set, which presented values between 0.63 and 1.17 (Figure 3).

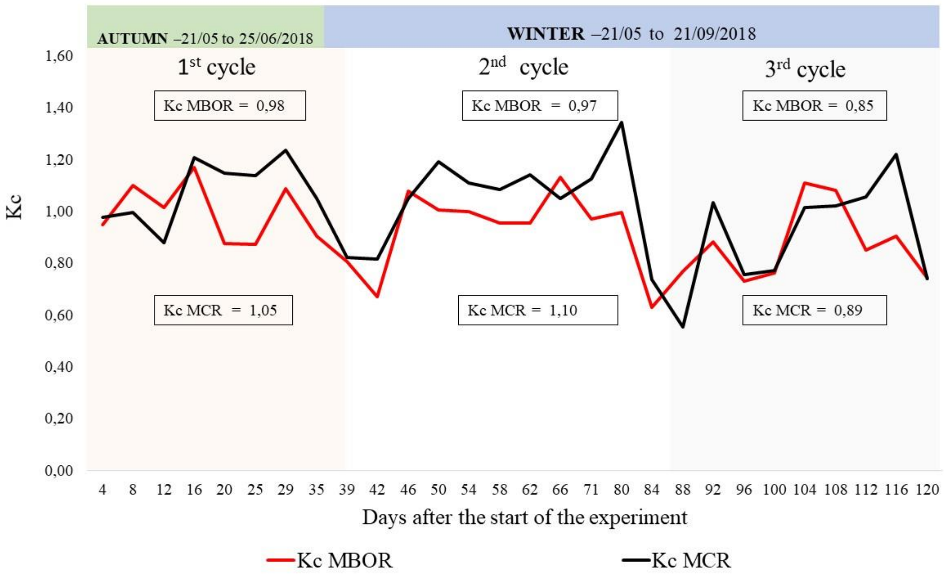

Figure 3. Crop coefficient (K_C) values for Marandu palisadegrass overseeded with different winter forage sets over the study cycles, Piracicaba/SP, 2018. K_C MBOR = average K_C estimated for Marandu palisadegrass overseeded with black oat + ryegrass, K_C MCR = average Kc estimated for Marandu palisadegrass overseeded with cereal rye + ryegrass.

The K_C values obtained in this study were found to be close to other values encountered in the literature. Souza (2017) determined Kc using weighing lysimeters in Marandu palisadegrass overseed with black oat and ryegrass and found values between 0.87 and 1.51. These values are higher in comparison of this study, possibly the reason was the temperature between the two winter periods. Sanches (2017) determined K_C values in Mombaça grass overseeded with black oat and ryegrass, in Piracicaba/SP, using weighing lysimeters and obtained values between 1.18 and 1.02.

In the scientific literature, no K_C values were encountered for cereal rye. For reference, there are studies with K_C determinations for wheat cultures (GAO et al., 2014), which are similar to cereal rye cultures. The authors obtained K_C values varying from 0.35 to 1.04.

CONCLUSION

It was possible to observe that the ET_C and K_C values determined by weight lysimeter indicate that the Marandu palisadegrass forage cover overseeded with cereal rye and ryegrass consumed more water in relation to the plot overseeded with black oat + ryegrass. This is an important aspect when considering the irrigation layer to be applied to meet the hydric needs of different winter forage crops.

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