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STRATEGIES FOR TARO (*Colocasia esculenta*) IRRIGATION

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Abstract: This study aimed to evaluate the taro (*Colocasia esculenta*), var. São Bento, in response to different irrigation strategies. The experiment was carried out at Ifes *campus* Santa Teresa, Brazil, at an altitude of 130 meters above sea level, using a randomized block design (RBD) with five treatments for the water availability factor of culture (f factor) equivalent to 0.1; 0.2; 0.3; 0.4 and 0.5, and four replications. Meteorological data were used to estimate the crop water demand, performing daily water balance using spreadsheets. We evaluated the applied water depth, the yield of commercial cormels and the water use efficiency by taro, due to the f factor. The results were submitted to analysis of variance and regressions. Increasing the f factor provided a reduction of applied irrigation depths. Lighter and frequent irrigations improved the development and yield of taro and can be recommended for its management.

Keywords: f factor, taro, cocoyam, yield, efficiency

INTRODUCTION

The taro (*Colocasia esculenta*), also known as cocoyam, is of great economic and social importance in many tropical and subtropical regions of the world, occupying a prominent place in the diet of many people in these regions (Huang et al., 2007). In Brazil, it is grown mainly in the states of the Mid-South. It is present in almost all the municipalities of Minas Gerais State, which is the state's largest producer of the country and it is explored in family farming. Taro presents fleshy cormels, with similar nutritional value of potato tubers (Brasil, 2010).

World production of taro in 2013 reached 9.976 million tons grown on 1.299 million hectares, and Nigeria was responsible for about 3.450 million tons, followed by China with 1.845 million tons and Cameroon with 1.551 million tons (FAO, 2014). However, the FAO estimates that only 145,000 tons are sold and the remainder is used in the food base of these people. Recent data are not found on the production of taro corms on the national scene of Brazil, but it is estimated that this is around 200,000 tons.

Despite the potential that culture has to develop in excess moisture environments, excessive shading and other climatic stress (Heredia Zárate, 1995), there is still a lack of information about it. Even the need for water for the culture is not consolidated, and most often is not linked to technical criteria, resulting in unnecessary expenditure of energy for irrigation and waste of water or under-utilization of irrigation system.

The expansion of irrigated areas, currently held, this tied to concerns about the availability of water for agriculture and energy costs associated with practice. Consequently, the adoption of strategies aimed to reduce the waste of water, without incurring losses in productivity (Coelho et al., 2005), become essential to the efficient use of these water and energy resources.

According to Doorenbos and Kassam (1979), the productivity of a culture is a function of complex biological, physiological, physical and chemical processes, which are determined by environmental conditions and genetic factors of culture itself. Thus, the realization of irrigation tends to raise the productivity of crops. However, only irrigation without an efficient management to consider the cultural and physiological aspects of the species, physical, chemical and physicochemical soil and particularities of the adopted irrigation system (Mantovani et al., 2007), just not provide a significant increase in productivity, but an expressive reduction of the costs associated with the cultivation.

Proper and strategic water management can be done using the water use efficiency (WUE) index for planning and irrigation decision-making, increasing the crop yield (Karatas et al., 2009). Thus, a good management strategy of irrigation is essential to save water without, however, endangering the crop yield (Jalota et al., 2006; Pereira et al., 2009).

In the case of taro, there is a shortage of technical information of Brazilian soils and climate conditions, and most of the work reported in researches comes from other countries (Gondim et al., 2007; Mabhaudhi et al., 2013). As regards, the water requirement of this culture is lack of clear information and it is not being known about water requirements in their phenological phases to conditions of Brazilian agricultural ecosystems. Therefore, the present study was due to evaluate the response of taro to different strategies of irrigation (f factors).

MATERIAL AND METHODS

The experiment was conducted in the Vegetable Crops sector of the Instituto Federal do Espírito Santo, *campus* Santa Teresa, Espírito Santo state, Brazil, as shown in Figure 1. The area is located in the coordinates latitude 19º48'36" south and longitude 40º40'48" west, has an altitude of 130 m above sea level, with soil classified predominantly as Latosol Yellow Eutrophic clayey, containing 63% of clay in its composition. In the area where the experiment was carried out, the field capacity (FC) is 32%; the permanent wilting point (PMP) is 20.6%; the bulk density is 1.16 g cm^{-3} and the root depth of the culture was 40 cm.

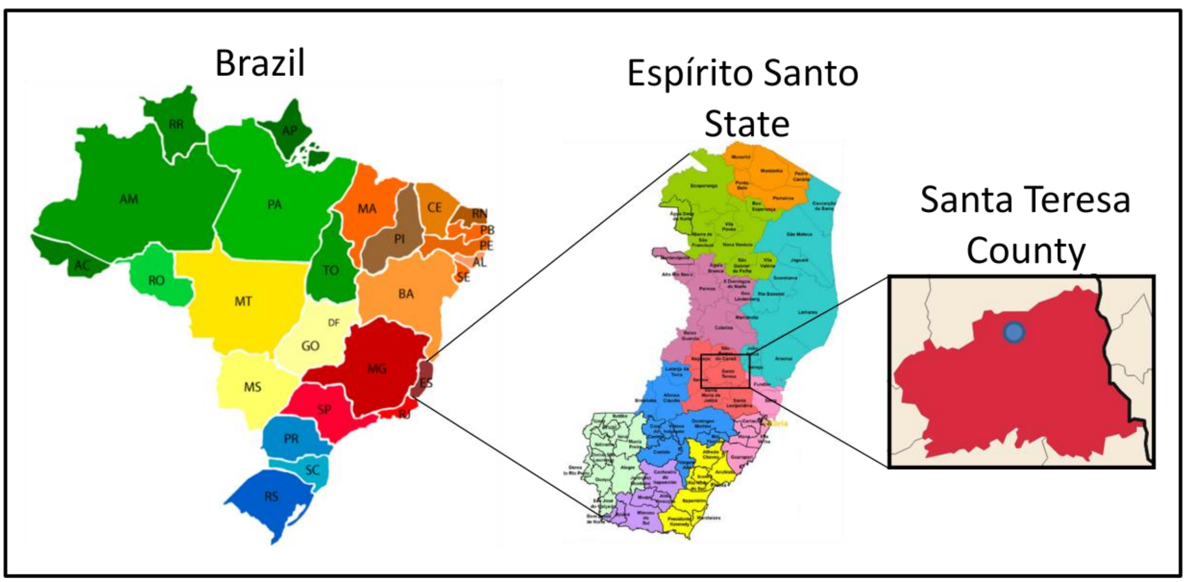

Figure 1. Localization of experimental area in Santa Teresa County, Espírito Santo State, Brazil.
**Camaravni (2017); Thinglink (2017); Wikipedia (2017). ** Map assembly made by the author.*

It was installed a drip irrigation system, divided in sectors, to irrigate the plots individually, according to the treatments. The irrigation periods were determined according to the water availability for the culture (f factor), established for each treatment, as shown in Table 1. Thus, irrigation was performed when the water in the soil was depleted equivalent to 10; 20; 30; 40 and 50% of the total water available, respectively, for the treatments T1, T2, T3, T4 and T5, in a randomized block design, with four replications. Figure 2 shows a part of the experimental area.

Figure 2. Taro cultivated in the experimental area, localized in the Instituto Federal do Espírito Santo, Santa Teresa *campus*.

The treatments were irrigated at different times, so when the irrigations occurred, the amount of water in the soil was different, which gave different soil water deficits for each treatment, as shown in Table 1.

Table 1. Treatments and their respective f factors and water deficits, in mm, at the time of irrigation.

Treatment	**T1**	**T2**	**T3**	**T4**	**T5**
f factor	0.1	0.2	0.3	0.4	0.5
Water deficits (mm)	7,3	14,6	21,9	29,2	36,5

The irrigation levels were determined, individually for each treatment, using spreadsheets, that calculated the water balance with climate measurements (maximum and minimum temperatures and the rain) and sporadic determination of soil water content with the stove method. The calculation of culture evapotranspiration is given by Equation 1 (Mantovani et al., 2009; Vieira et al., 2015). The reference evapotranspiration was determined by Hargreaves and Samani method (Allen et al., 1998). The single crop coefficient (Kc) used for taro was proposed by Fares (2008), which suggests the following values: Kc initial: 1.05 in the first two months planting; Kc mid: 1.15, the second to the sixth month after planting and Kc final: 1.1, the sixth month until harvest.

$$ETc = ET_0 \, K_C \, K_S \, K_L \qquad (1)$$

Where:

ET_C - crop evapotranspiration, mm d^{-1};

ET_0 - reference evapotranspiration, mm d^{-1};

K_C – single crop coefficient, dimensionless;

K_S – water stress coefficient, dimensionless;

K_L - correction factor due to the drip irrigation, based on the wetted and shaded area, dimensionless.

The irrigation system was assessed following the method proposed by Keller and Karmeli (1975) and determined the Distribution Uniformity coefficient (DU) of the irrigation system. These authors suggest collecting flow at 4 points along the lateral line, i.e., the first dripper, the emitters located at 1/3 and 2/3 of the length of the line and the last dripper. The lines selected within the sector should be: first, those located at 1/3 and 2/3 of the length and the last lateral line, assessing 16 values as a whole.

It was cultivated taro var. São Bento. Before the implementation of the crop, the experimental area was prepared and fertilized. Taro corms were used for the implementation of the experiment and they were distributed in the planting furrows so that the yolks placed face up. Then the corms were covered with soil until about two centimeters above the apex of the yolks.

The yield performance was evaluated from the average productivity of cormels obtained in treatments, and quantified the production of commercial cormels. The classification of the cormels was performed according to the recommendation of Puiatti et al. (1990), from the transverse diameter, being large (> 47 mm), medium (33-46mm), and little cormels (<33mm). For the aggregation of commercial cormels it was considered the sum of large and medium cormels.

The water use efficiency was determined by the ratio of the values of productivity (t ha^{-1}) and the respective applied irrigation depth (mm), in each treatment, and the results expressed in kg m^{-3} as cited by Sammis (1980) and Vieira et al. (2015).

The data were submitted to analysis of variance and regressions, and the coefficients were analyzed with 1% level of probability by the F test.

RESULTS AND DISCUSSION

Figure 3 shows the relationship between the total water depths depending on the soil water depletion. It is observed that the increase of the f factor has provided a reduction of the total water depth applied to the culture. At T1 treatment, with f factor 0.1, the total water depth was 454 mm and at T5 treatment, the largest f factor, 397 mm was demanded by the culture, approximately 12.6% of difference. This occurs because for higher f factor values, the intervals between irrigations (irrigation frequency) become larger, which promotes greater soil water depletion by reducing its moisture and consequent reduction in evapotranspiration and therefore lower replacement water through irrigation.

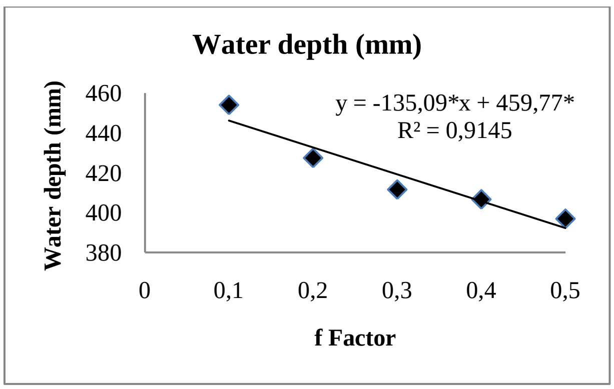

Figure 3. Total water applied in different irrigation frequencies (f factor). *Significant at the 1% level of probability by the F test.

In Figure 4 the yield of taro in relation to f factors. It is observed that the increase in the irrigation intervals provided a reduction of yield in commercial cormels.

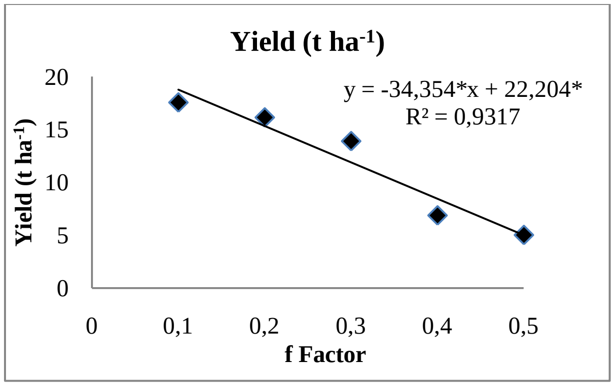

Figure 4. Average yield of taro cultivar "São Bento" under different irrigation frequencies (f factor). *Significant at the 1% level of probability by the F test.

The T1 and T2 treatments had the highest productivity among all tested. This occurred because with the high frequency of irrigation, the plants were subjected to less or no water stress, unlike the T4 and T5 treatments that received the largest individual irrigation levels, but in more distant periods, which may be caused drought stress and thus reduced plant yield.

The T5 treatment plants had few or no large cormel, predominantly medium and small cormels, in addition to the mother cormel, occurring cormels damaged by rot, which are not viable to trade. The T1 and T2 treatments presented a number of large and medium-sized cormels in a satisfactory amount for each class, with low number of small and damaged cormels.

It is observed a tendency to increase yield by reducing the irrigation interval. The highest yield of commercial cormels was achieved with the treatment T1, and the observed mean of 17.55 t ha^{-1}. For the treatment T5 the average yield achieved was 5.01 t ha^{-1}, 71.4% lower than the first. As cited by Caesar (1980), stress conditions such as lack of water led to slow growth and retarded development of cormels, as in this experiment.

In Figure 5, is observed the water use efficiencies in relation to f factors. The greater efficiency can be seen at T1, then T2 with values of 3.87 and 3.77 kg m^{-3}, respectively. In these treatments the soil remained wetted between intervals of irrigation, which provided better conditions for the development of culture and to achieve high yield. Even applying greater water depths, it is recommended to apply lighter and frequent irrigations for taro cultivation.

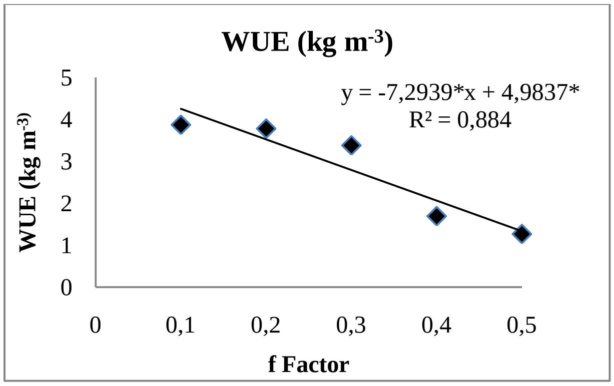

Figure 5. Water Use Efficiency (kg m^{-3}) of taro cultivar "São Bento" under different irrigation frequencies (f factor). * Significant at the 1% level of probability by the F test.

According to Vicente and Vicente (2004) and Salomão et al. (2014), when the irrigation interval is too long, the friability of the soil immediately obtained after irrigation undergoes a progressive alteration and, depending on the texture, can at the end of the period, present hard consistency, hindering the penetration of roots of cultivated plants. The local soil used has a high clay content, with greater consistency at lower humidity levels. In this case it is important to increase the frequency of irrigation, establishing temporarily lower irrigation frequency, a condition that will keep the moist topsoil for a longer period of time.

CONCLUSIONS

Increasing the f factor provided a reduction of applied irrigation depth. Lighter and frequent irrigations favor the development and productivity of taro and can be recommended for their management.

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