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YIELD OF CONILON COFFEE UNDER DIFFERENT IRRIGATION MANAGEMENTS

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1 ABSTRACT

Water deficit is one of the main problems in the development of coffee culture. To obtain better productivity and quality, the practice of irrigation is adopted by producers worldwide. However, when this practice is not managed properly, cultivated plants may have different responses. Thus, this experiment aimed to evaluate the yield of conilon coffee under irrigated conditions, irrigated with a deficit of 50% of the culture evapotranspiration and non-irrigated. The experiment was conducted in a 3 x 13 split plot scheme, with the irrigation management factor at 3 levels and the clone factor at 13 levels. The data obtained were subjected to analysis of variance and when significant compared using tests of means. Analyzing the effect of the irrigation management factor, it is possible to observe that there was no statistical difference between the levels irrigated with 50% of ETc and non-irrigated. At the level irrigated with 100% ETc, and the best value of yield was observed. The values closest to the average of the variety were obtained by clones V1, V5, V8, V9, V11, V12 and V13.

Keywords: Evapotranspiration; *Coffeea Canephora*; Productivity.

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2 RESUMO

O déficit hídrico é um dos principais problemas no desenvolvimento do cafeeiro. Para obter melhor produtividade e qualidade, a prática da irrigação é adotada por produtores em todo mundo. Entretanto, quando esta prática não é manejada de forma adequada as plantas cultivadas podem apresentar diferentes respostas. Com isso, objetivou-se nesse experimento a avaliação do rendimento do cafeeiro conilon em condições irrigadas, irrigadas com déficit de 50% da evapotranspiração da cultura e sem irrigação. O experimento foi conduzido em esquema de parcelas subdivididas 3 x 13, com o fator manejo da irrigação em 3 níveis e o fator clone em 13 níveis. Os dados obtidos foram submetidos a análise de variância e quando significativos comparados utilizando testes de médias. Analisando o efeito do fator manejo da irrigação é possível observar que não ocorreu diferença estatística entre os níveis irrigado com 50% da ETc e sem irrigação. No nível irrigado com 100% da ETc foi observado o melhor valor de rendimento. Os valores mais próximos da média da variedade foram obtidos pelos clones V1, V5, V8, V9, V11, V12 e V13.

Keywords: Evapotranspiração; *Coffeea Canephora*; Produtividade

3 INTRODUCTION

Brazil is the main coffee producer in the world, the state of Espírito Santo is responsible for 70% of Brazilian conilon coffee, totaling 20% of the coffee grains produced worldwide (USDA, 2020).

One of the main limiting factors for the growth, development and production of coffee is the water deficit (ARAUJO et al., 2011). According to the agroclimatic zoning for cultivating Conilon coffee in the State of Espírito Santo, it points out that in almost every producing region there are productivity limitations due to the water deficit in critical growth phases (PEZZOPANE et al., 2010). Thus, it is necessary to conduct cultivation predominantly under irrigation (COVRE et al., 2015).

The practice of irrigation when well implemented and managed, can provide an increase in productivity and quality of production, and may even double production, provided that along with irrigation, production technologies that are recommended for the crop are incorporated (FERRÃO et al., 2012). However, in most irrigated areas, rational water management is not conducted, causing an excessive application or deficit of water, resulting in low productivity and economic losses to the producer (REIS; SOUZA; PEREIRA, 2015). Thus, it is necessary to know the relationship between the water deficit and its effects on the development of the plant, which is extremely important for understanding the responses of crops to water stress (RODRIGUES et al., 2015).

Knowing how much will be harvested is always the information desired by the producers, and it is common to estimate its production according to the crop yield, that is, the volume of coffee harvested in the crop necessary to obtain a 60 kg bag with coffee beans. Processed raw material (LIMA; CUSTÓDIO; GOMES, 2008).

Based on this, this study aimed to evaluate the yield of thirteen clones of conilon coffee variety Vitória under conditions irrigated with 100% of the crop evapotranspiration, 50% of the crop evapotranspiration and in non-irrigated conditions.

4 MATERIALS AND METHODS

The experiment was performed at the Federal Institute of Education, Science and Technology of Espírito Santo - Campus Alegre, Fazenda Caixa D'Água, Rive district, located at latitude 20º25'53 " S and longitude 41º27'25 " W, average altitude 137 m and average annual rainfall of 1250 mm. In an area of approximately 0,42 ha cultivated of Coffea canephora Pierre, variety 'Conilon Vitória Incaper 8142', consisting of thirteen clones. According to the Köeppen classification, the region's climate is of the “Aw” type with a dry season in winter, where the average annual temperature is 23,1 ºC.

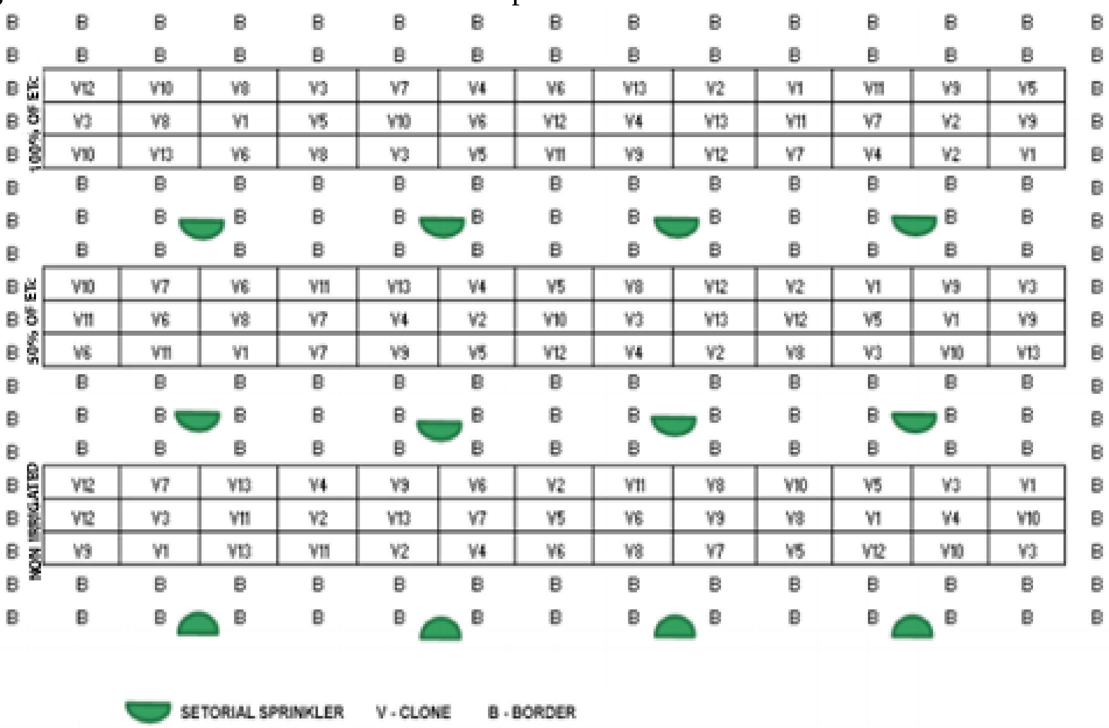
The soil of the place was classified as Red Yellow Latosol, with a sandy-clay texture and the planting of the clones seedlings was conducted in November 2010, adopting a 3 x 1.1 m spacing. The table below shows the physical-hydric characteristics of the soil in the study area.

Table 1. Physical-water characteristics of the soil in the study area.

Depth	Field Capacity	Withered Point	Specific Density	Root System Depth
0 – 30 cm	28,06%	14,93%	1,121%	20 cm

The experimental design used was a 3 x 13 split plot scheme (management x clone), with the plots being the irrigation management factor in three levels (irrigated, irrigated with 50% of the crop evapotranspiration and non-irrigated) and in the subplots the clone in thirteen levels (V1; V2; V3; V4; V5; V6; V7; V8; V9; V10; V11; V12 and V13), in a randomized block design, with three replications. In the figure below, the sketch of the experiment (Figure 1).

Figure 1. Sketch with the scheme of the experiment.



The irrigation system used in this experiment was a conventional sprinkler irrigation system consisting of three lateral lines was used, each presenting four sector sprinklers spaced by 18 x 18 m, with nozzles 5.6 x 3. The management of irrigation adopted was climate management, in which the reference evapotranspiration (ETo) was estimated by the method of Hargreaves and Samani (1985) and using a kc of 1.1. To obtain the climatic data, a meteorological station was installed near the crop. A 4-day fixed irrigation shift was defined for the "irrigated with 100% ETc" management plants and an 8-day irrigation shift for the "irrigated with 50% ETc" management plants.

$$ETo = 0{,}0023 \left(\frac{Ra}{2{,}45}\right) (Tmax - Tmin)^{0{,}5} (Tmed + 17{,}8) \quad (1)$$

In which: T med- average temperature (ºC); Tmed = 0.5 (Tmax + Tmin); T max- maximum temperature (ºC); Tmin- minimum temperature (ºC); Ra- solar radiation at the top of the atmosphere ($MJ.m^{-2}.d^{-1}$).

$$ETc = ETo \times kc \quad (2)$$

In which: ETc - culture evapotranspiration, mm d^{-1}; ETo - reference evapotranspiration, mm d^{-1}; and Kc - culture coefficient, dimensionless.

In the graphs below, it is possible to observe the average maximum and minimum temperatures (Figure 2), and precipitation, reference and culture evapotranspiration, and the irrigation depths applied in the managements during conducting the experiment (Figure 3).

Figure 2. Maximum, minimum and monthly average temperatures of the study area during the period of conduction of the experiment.

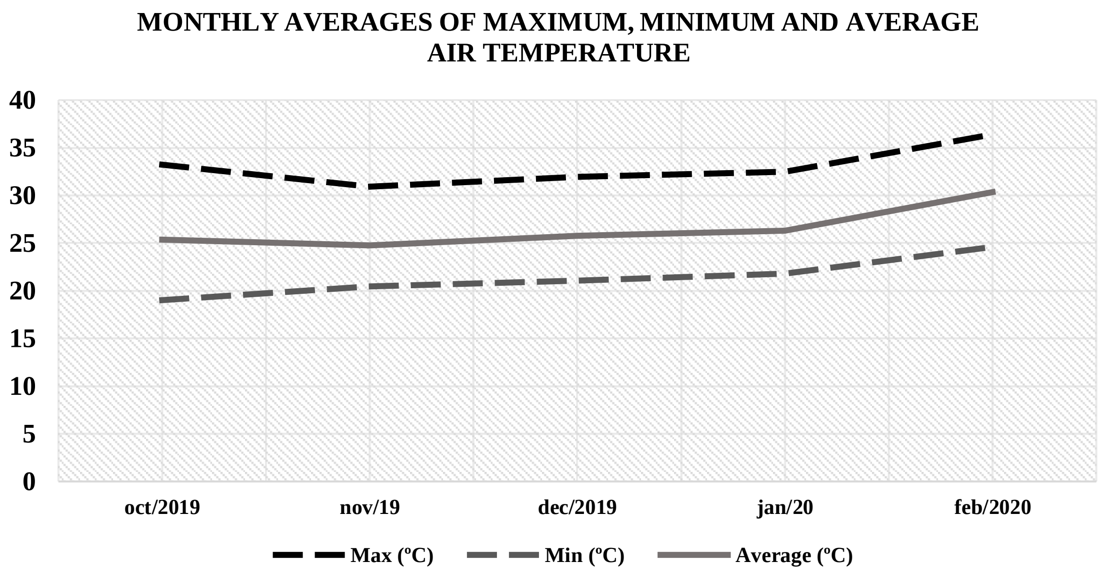
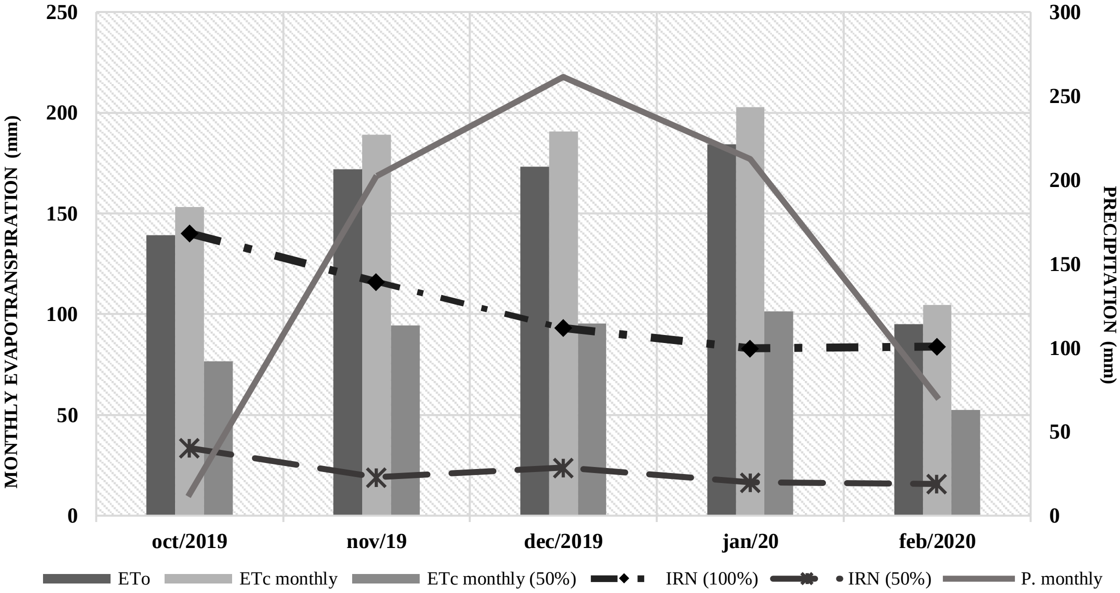


Figure 3. Monthly reference evapotranspiration data, crop evapotranspiration, irrigation depths and precipitation.



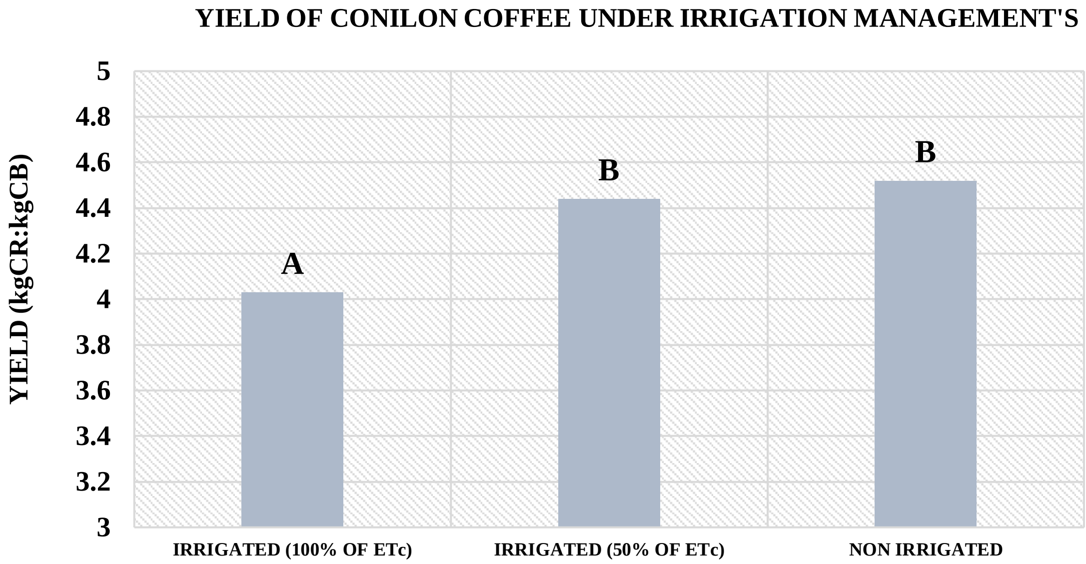
The harvest was conducted using as a criterion at least 80% of the ripe fruits, considering that within the variety there are clones of early, intermediate and late maturation, and between the managements there are different times of the maturation of the coffee tree. The yield was established by the relationship between the quantities of freshly harvested coffee corresponding to a sample of 2.0 kg and the quantity of coffee subsequently processed (KgCR per KgCB).

The data obtained in the experiment were tabulated in a spreadsheet and subjected to analysis of variance and when significant, the means were compared using the Scott-Knott test for comparison between the clone factor, for comparison between and the management factor, the Tukey test was applied at both 5% probability, using the software R 4.0.2 (R CORE TEAM, 2020) with the aid of the ExpDes.pt package (FERREIRA; CAVALCANTI; NOGUEIRA, 2017).

5 RESULTS AND DISCUSSION

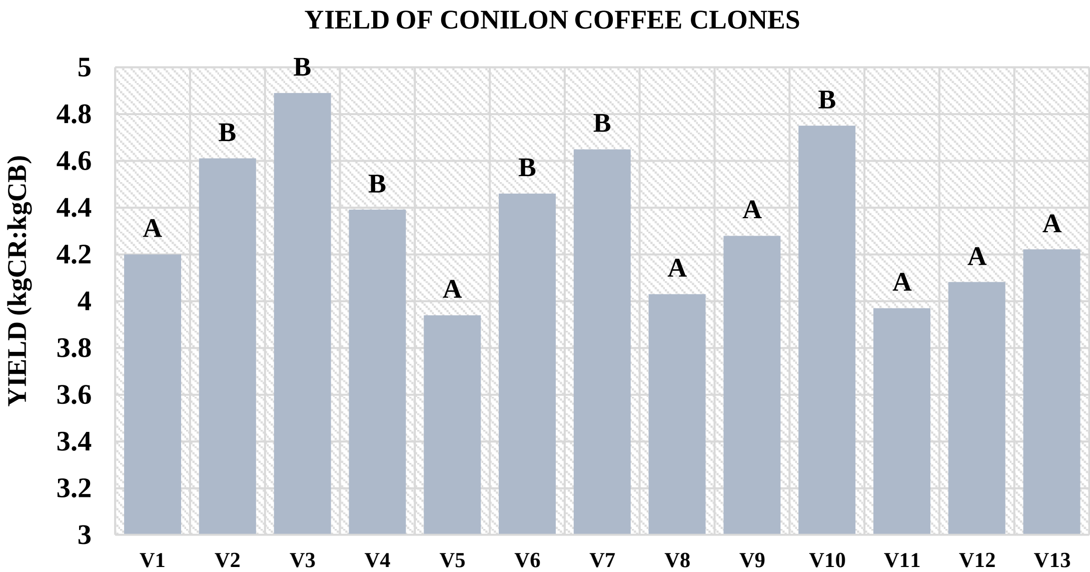
By analysis of variance, it was found that there was no significant effect for the Irrigation Management x Clones interaction, but the irrigation management plot and clone subplots were significant. In the graphs below it is possible to see the result of the analysis of the simple effect for the irrigation management (Figure 4) and clones (Figure 5).

Figure 4. Yield of Conilon coffee as a function of irrigation management.



Means followed by equal letters do not differ by the Tukey test at a 5% probability level.

Figure 5. Yield of Conilon coffee according to clones.



Means followed by equal letters do not differ by the Scott-Knott test at a 5% probability level.

Analyzing the effect of the plot for the comparison of means between the levels of irrigation management, it was observed that there was no statistical difference between plants in non-irrigated and irrigated with 50% of ETc, however, there was a difference compared with the irrigated management with 100% of ETc. It is observed that the plants of the level without irrigation presented a CR/CB index of 4.52:1 and plants of the level with 50% of ETc an index of 4.44:1 and plants of the level with 100% of ETc, showed an index of 4.03:1. According to Ferrão et al. (2007) this index varies between 3.3:1 to 5.2:1, for conilon coffee, which is influenced by its genetic material, and that this index may increase as green fruits are harvested in quantity.

According to Fonseca et al. (2004), this relation for the variety 'Conilon Vitória' is 3.9:1, that is, 3.9 kg of freshly harvested coffee is needed to obtain 1.0 kg of processed coffee. Based on the analysis of Figure 4, it is possible to observe that plants irrigated with 100% of ETc, presented the index closest to that indicated by Fonseca et al. (2004) as a yield index for the variety used in this study. One of the explanations for the better yield obtained in plants irrigated with 100% ETc, is due to the adequate and sufficient supply of water in the fruit expansion phase, which occurred in the period between 10th and 17th weeks after flowering, this is one of the most critical stages for the coffee tree, where water scarcity slows fruit growth, preventing them from reaching their potential size, resulting in low sieves and a drop in yield (CAMARGO, 1987). In this context, the effect of irrigation is notorious as an important tool to reduce the drop in productivity, increase yield and increase the physical quality of the final product. Since, significant decreases in the productivity of conilon coffee are related to water deficiency in the times of flowering, formation and filling of beans (GALEANO et al., 2016.; CAFÉ, 2017.; DARDENGO et al., 2018). However, the low difference between the yields obtained as a result of irrigation management, is due to the good rainfall obtained from October 2019 to January 2020, as can be seen in Figure 3. Analyzing Figure 3, it is possible to observe that precipitation occurred mainly in the coffee-flowering period and in the grain filling phase. In December 2019, the precipitation value obtained was even higher than the evapotranspiration of the crop, causing even a waste of water to occur. Although precipitation is a natural factor that acts favorably for coffee development and productivity, irrigated management still has the best yield value, reinforcing the benefit of this practice for crop development, even in a 50% deficit, yield was even better than in conditions non-irrigated.

When analyzing Figure 5, it is possible to observe that the two groups are formed. Group A, composed of clones: V1, V5, V8, V9, V11, V12 e V13. And group B, composed of clones: V2, V3, V4, V6, V7, V10.

In group B, the index varied between 4.89:1 to 4.39:1, this group being composed by the clones that presented the highest yield values, requiring more freshly harvested coffee to produce 1.0 kg of processed coffee. Furthermore, in group A, this index ranged from 4.28:1 to 3.94:1, with the clones of this group being the values with the best yield, and in these clones, smaller quantities of freshly harvested coffee are needed to produce 1.0 kg of processed coffee. Highlighted for clones V5 and V11 that presented an index of 3.94:1 and 3.97:1 indicated by Fonseca et al. (2004) as the index of the variety under study.

6 CONCLUSIONS

The irrigation acted beneficially on the coffee tree, being the management irrigated with 100% of ETc, with the best yield index in relation to the non-irrigated and irrigated management with 50% of ETc.

There was no statistical difference between the yield of plants irrigated with 50% of ETc and plants of management without irrigation.

Clones V5 and V11 showed the best yield rates of the variety in the 2019/2020 harvest.

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