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# Initial Development of Clonal Seedlings of *Coffea canephora* Submitted to Different Irrigation Depth

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***Authors' contributions***

*This work was carried out in collaboration between both authors. Authors ALRP and VSO designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors ALRP and VSO managed the analyses of the study. Authors ALRP and VSO managed the literature searches. Both authors read and approved the final manuscript.*

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## ABSTRACT

The objective of this study was to evaluate the effect of different irrigation depth on initial development of *Coffea canephora* seedlings. The study was carried out at the farm Perobas, in the municipality of Rio Bananal, Espírito Santo, Brazil. The experimental design was completely randomized, with five treatments, comprising different depths of irrigation, being: 5, 7.5, 10, 12.5 and 15 mm dia$^{-1}$. At 55 days after planting the seedlings were evaluated for characteristics:stem diameter, plant height, dry mass of aerial part and dry mass of the root system. The stem diameter and dry mass of the root system presented an inverse behavior to the increase of the irrigation depth. The plant height and dry mass of aerial part presented an increasing effect in relation to the variation of the irrigation depth. The 5 mm dia$^{-1}$ irrigation depth provides the best result for development in the initial stages of the root system of the seedlings, while the irrigation depth of 15 mm dia$^{-1}$ favored a greater accumulation of dry mass of aerial part of the seedlings.

*Keywords: Coffea canephora; seedling quality; irrigation management.*

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## 1. INTRODUCTION

Coffee farming has great economic and social importance in the world agricultural sector, generating in different sectors divisions jobs [1]. The State of Espírito Santo is an important coffee producer, being the largest Brazilian coffee conilon producer (*Coffea canephora*), producing 5.38 million bags benefited in the year 2016 [2]. This production is guaranteed by a very large area devoted to cultivation, about 260,032 thousand hectares [2] and consequently, there is a very large demand for seedlings, since this crop needs a constant renovation of the canopy to guarantee levels productivity.

According to Tomaz et al. [3], the production of quality seedlings is the main factor for the success of the formation of a coffee crop, since changes of quality favor the initial formation of the plant and guarantee a good development of the crop. The quality of a seedling is associated with several factors of fundamental importance in the success of a coffee crop, among them, the volume of the container, the substrate used and the availability of water. The water deficit is probably the most limiting of the productivity, since in addition to affecting the water relations of the plants, by the alteration of their metabolism [4].

The lack or excess of water creates an environment unfavorable to the development of seedlings. The lack of water limits the absorption of nutrients, leading the plant to water stress, on the other hand, the excess favors the appearance of diseases, causes leaching of the nutrients present in the substrate, besides causes socio-environmental problems due to the waste of water [5].

Studies of the water depth, applied directly on species of seedlings, has been used in several experiments, and demonstrates excellent results [6,7,8]. However, works involving *Coffea canephora* seedlings is excessive. Thus, the objective of this study was to evaluate the effect of different irrigation depth on initial development of *Coffea canephora* seedlings.

## 2. MATERIALS AND METHODS

The experiment was installed and conducted in the seedling nursery of the farm of Perobas property, in the municipality of Rio Bananal, Espírito Santo, Brazil, at the geographic coordinates: latitude 19°10'42.2" South, longitude 40°23'37.4" West and altitude of 110 m, between the months of September to November of 2016.

The seedlings were produced in 0.290 liter tubes. As a substrate was used 70% BIoplant® commercial product, 28% coffee bean addition and 2% Osmocote®. The tubes were arranged in trays used properly to facilitate the organization and promote physical support. The genotype used in this research was clone V13 of the Conilon clonal coffee variety Vitória Incaper 8142.

The design was completely randomized with 5 treatments and 5 replicates, whose treatments were different irrigation depths. The depths used were: T1: 5 mm $d^{-1}$; T2: 7.5 mm $d^{-1}$; T3: 10 mm $d^{-1}$; T4: 12.5 mm $d^{-1}$; and T5: 15 mm $d^{-1}$.

The production nursery is constructed with polyamide mesh cover with 50% shading, and waterproof translucent plastic canvas to insulate the effect of natural precipitation. Irrigation was performed daily, from 6:00 am to 6:00 pm, at 7 minute intervals for 10 seconds. The operating intervals were obtained through the relation between the volume of water applied by the issuer and its coverage area. The total operating time of the system provided the daily application of the desired depth in each treatment. The microjet irrigation system was used, located above the seedlings. Each treatment had a different density of emitters in order to reach the required depth. The system was constantly monitored to maintain optimum pressure and to avoid possible clogging of the emitters.

At 55 days after planting the cuttings, the following morphological characteristics: stem diameter (SD), measured with pachymeter, in mm; plant height (PH), measured with graduated ruler, in mm; dry mass of aerial part (DMAP), measured in g; dry mass of the root system (DMRS), measured in g.

The results were submitted to analysis of variance, when significant effects were observed considering the error of 5%, the results were adjusted in regression analysis by the orthogonal polynomials method.

## 3. RESULTS AND DISCUSSION

Table 1 shows the results of the analysis of variance for the characteristics evaluated. Note that there was a significant difference ($p \leq 0.05$)

for the variables harvesting stem diameter (SD), plant height (PH), dry mass of aerial part (DMAP) and dry mass of the root system (DMRS) in relation to applied irrigation depth.

The linear regression model was the one that best described the effect of the irrigation depth on the stem diameter (Fig. 1). It is verified that this variable presented an inverse behavior to the increase of the irrigation depth. The irrigation depth influenced the elongation of the initial sprouting of the cuttings. In stakes that received smaller depth, the shoots were still in the initial stages of growth, presenting both vertical growth and the radial growth of the meristem, on the other hand, in stakes that received the largest depth, the initial shoots were in a stage of development more advanced showing greater vertical growth. The largest stem diameter estimated was 3.29 mm obtained with the 5 mm $d^{-1}$ depth and the smallest diameter estimated was 2.93 mm obtained with the 15 mm $d^{-1}$ depth.

The plant height (Fig. 2), showed an increasing effect in relation to the variation of the irrigation depth. This behavior was also observed by Lopes et al. [9], when evaluating the quality of seedlings under different irrigation depths. The model that best described the effect of the treatment on the variable was the linear regression, with the largest length of estimated aerial part was 52.13 mm obtained with a depth of 15 mm $d^{-1}$ and the lowest estimated length of 25.25 mm was obtained with the 5 mm depth $d^{-1}$.

The plant height, is the first characteristic observed when choosing seedlings for planting, followed by the number of leaves, the color of the leaves, the stem diameter, the number of shoots and, finally, the root system. In this way, the plant height becomes a variable that defines the commercial interest. The dry mass of the root system (Fig. 4), in the initial period of development, shows an inverse behavior to the behavior of the plant height and dry mass of aerial part. Often, the root system is not a decisive factor for the acquisition of molt, a fact attributed to the need for a destructive analysis to assess its quality, or even a lack of technical

**Table 1. Variance analysis with Source of Variation (SV), Degree of Freedom (DF) and Average Squares (AS) of the characteristics Stem Diameter (SD), Plant Height (PH), Dry Mass of Aerial Part (DMAP) and Dry Mass of the Root System (DMRS) of conilon coffee plants**

| SV | DF | AS | | | |
|---|---|---|---|---|---|
| | | SD | PH | DMAP | DMRS |
| Treatment | 4 | 0.136852* | 617.253845* | 0.035965* | 0.044524* |
| Residue | 20 | 0.026621 | 120.813945 | 0.009896 | 0.057816 |
| CV% | | 5.24 | 28.40 | 33.52 | 13.75 |

**significant at 5% by the F test; coefficient of variation (CV)*

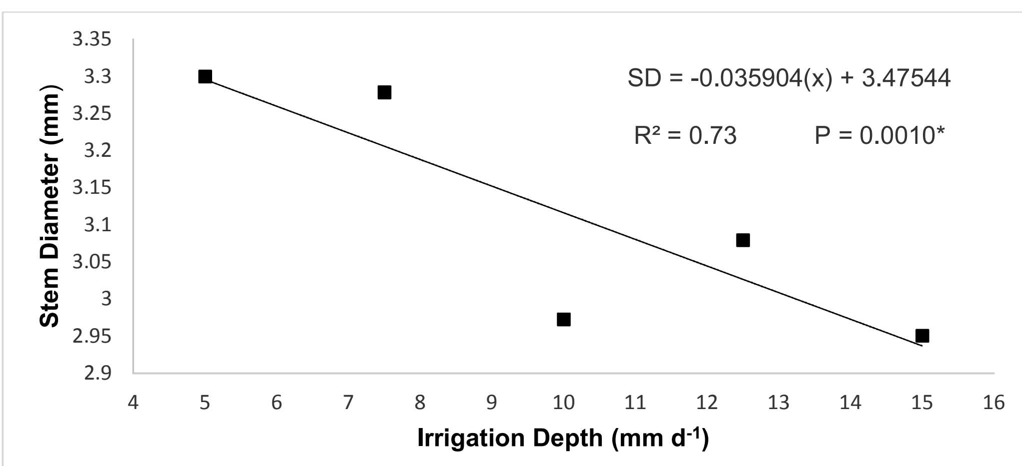


**Fig. 1. Estimating the collecting Stem Diameter (SD) of conilon coffee seedlings as a function of the irrigation depth**

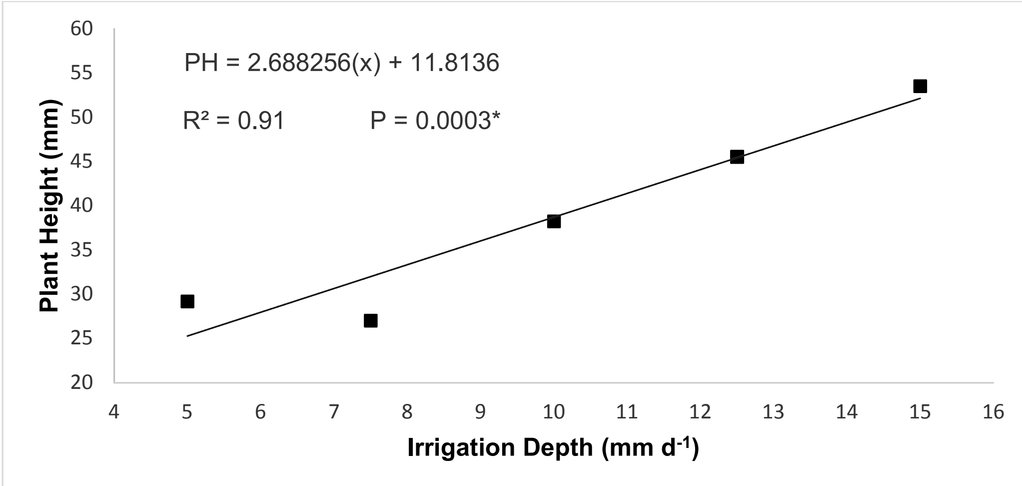


**Fig. 2. Estimating the collecting Plant Height (PH) of conilon coffee seedlings as a function of the irrigation depth**

knowledge, which leads to problems occurring during the establishment of molt in the field. A well developed root system is critical to successful transplanting.

Another characteristic evaluated was the dry mass of aerial part (Fig. 3), showed a growth behavior in relation to the increase of the applied depth. Similar results were observed by Araújo et al. [10], that when evaluating the influence of the water deficit on the initial development of conilon coffee cultivars, found a decrease in the dry mass of aerial part of the evaluated seedlings with the increase of the water deficit. This indicates that, the water availability favors the development of the aerial part of the plants.

Dardengo et al. [11], studying the water deficit in conilon coffee, state that the water deficit reduces the total dry mass of the coffee tree. Martins et al. [12], consider that a greater water availability influences in a positive way the accumulation of dry mass of aerial part of conilon coffee. In physiological parameters, the greater availability of water to a vegetable within its range of suitability, favors the biological processes necessary for its development. Mathematically, this was best described by the linear regression model, with the highest value dry mass of aerial part equal to 0.394 g, obtained with the 15 mm depth, and the lowest estimated value equal to 0.199 g, obtained in the 5 mm dia-1 depth. Mathematically, this was best described by the linear regression model, with the highest value of dry mass of aerial part equal to 0.394 g, obtained with the 15 mm $d^{-1}$ depth, and the lowest estimated value equal to 0.199 g, obtained in the 5 mm $d^{-1}$ depth.

It was also evaluated the dry mass of the root system (Fig. 4) this presented growth inversely proportional to the increase of the irrigation depth. Martins et al. [12], observed that in the early stages of development of conilon coffee, the supply of smaller depth up to 90 days of development provided more dry mass of the root system.

The effect of the irrigation depth on accumulation in the dry mass of the root system was better described by the linear regression model. The highest estimated value for this variable was obtained on the 5 mm $d^{-1}$ depth, with 0.442 g.

In the evaluation spectrum, the dry mass of the root system showed a decreasing behavior in relation to the increase of the irrigation depth, this conflicts with the physiological tendency of the plant observed and described by some authors [10], who observed an increasing effect of the dry mass accumulation in the root system in relation to the increase of the depth. This can be explained by the fact that under these conditions the supply of water supplied to the plant was more than necessary for physiological stimulation to occur. Thus, the accumulation of dry mass in the upper depth was more directed to the growth of the aerial part of the plant (Fig. 3 and Fig. 4), since the water availability favors the growth of the aerial part of conilon coffee [10].

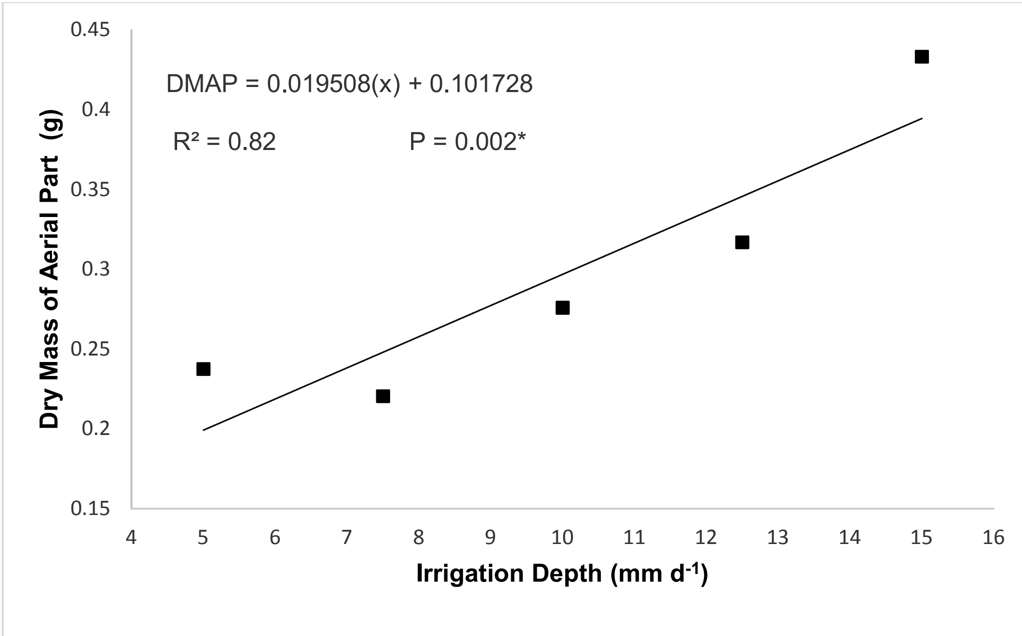


**Fig. 3. Estimating the collecting Dry Mass of Aerial Part (DMAP) of conilon coffee seedlings as a function of the irrigation depth**

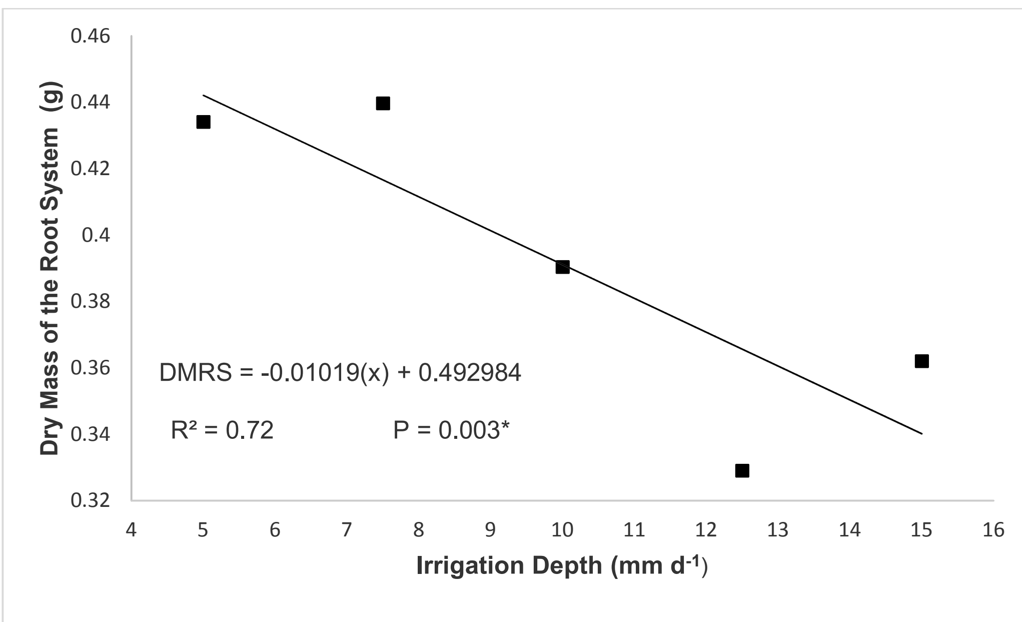


**Fig. 4. Estimating the collecting Dry Mass of the Root System (DMRS) of conilon coffee seedlings as a function of the irrigation depth**

The contact between the root surfaces and the soil provides the water absorption by the roots, this contact is maximized by the root growth in the soil reducing the resistance of the soil-root interface to the passage of water [13]. There is also the hydrophobic effect, which the older tissues of the root system have due to the presence of subepidermal protective tissue, avoring the absorption of water in newer root tissues. When subjected to a lack of water condition on the substrate, the plant activates mechanisms that promote root growth by increasing the amount of new roots to maximize water absorption.

The quality of seedlings depends on multiple factors that interact, so one should not take only one variable as determinant for the quality of conilon coffee seedlings at a certain stage of development. Commercially, we have taken characteristics exclusively related to the stage of development of the aerial part of plants, as a decisive factor for determining the quality of conilon coffee seedlings. With this, difficulties arise in the initial establishment of the seedlings in the field, since the adequate development of the root system provides greater conditions of initial development and resistance to the abiotic stresses that happen due to the change of environment, due to the process of leaving the seedling from the nursery to the field.

Based on the results obtained, it was observed that, in the treatments in which smaller irrigation depth were provided, they induced a higher deposition of dry mass of the root system and root growth. Whereas, the treatments that provided higher irrigation depths, induced higher deposition of dry mass of aerial part and plant height, confirming that the correct management of irrigation water is fundamental for the good growth of the same.

## 4. CONCLUSION

The 5 mm dia$^{-1}$ irrigation depth provides the best results for development in the early stages of the root system, favoring a higher dry mass deposition, while the 15 mm dia$^{-1}$ irrigation depth favors greater accumulation of dry mass of aerial part during the initial phase of the clonal seedlings of *Coffea canephora*.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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