YIELD, QUALITY AND WATER CONSUMPTION OF CONILON COFFEE UNDER IRRIGATED AND DRYLAND MANAGEMENTS

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ABSTRACT: In this study the goal was to make an assessment and comparison of the yield, quality and water consumed by the Conilon coffee plants under irrigated and dryland types of cultivation, from seedlings raised in different containers and under varying shading levels. The experiment which extended from December 2007 to April 2012 was performed at the IFES, Alegre-ES Campus and involved the study of a total of four crops. The findings showed that the irrigated plants had 162% higher yield on average than did the rainfed plants. For the irrigated plants, the yield indices achieved were 4.5 kg of coffee of the planted / benefited area; 1.9 kg of coconut / beneficiated coffee and 5.6 balms of 80 L sc^{-1}; whereas, for the rainfed plants, the values recorded were 8.2 kg of coffee from the benefited field; 3.1 kg of coconut / beneficiated coffee and 12 balloons of 80 L sc^{-1}. The Conilon coffee grains harvested from the irrigated plants were superior in quality to those from the rainfed plants. For the irrigated plants, the water consumed on average was 7.9 m^3 per plant, while for the rainfall-dependent crop, it was 4.95 m^3. For the irrigated and rainfed plants the relations between the water consumption / kg of the beneficiated coffee was 8.8 m^3 and 30.3 m^3, respectively. The type of container and levels of shading exerted no influence on the Conilon coffee with respect to productivity, yield and quality.

Index terms: *Coffea canephora,* irrigation, productivity, growth.

RENDIMENTO, QUALIDADE E CONSUMO DE ÁGUA DO CAFEEIRO CONILON SOB MANEJO IRRIGADO E DE SEQUEIRO

RESUMO: Objetivou-se com este trabalho avaliar e comparar o rendimento, a qualidade e o consumo de água do cafeeiro conilon irrigado e de sequeiro, oriundo de mudas formadas em diferentes recipientes e níveis de sombreamento. O experimento foi conduzido no IFES, Campus de Alegre-ES, no período de dezembro de 2007 a abril de 2012, totalizando-se quatro colheitas. O valor médio de produtividade de plantas irrigadas foi 162% superior ao de plantas de sequeiro. Os índices de rendimento obtidos em plantas irrigadas foram de 4,5 kg de café da roça/beneficiado; 1,9 kg de café coco/beneficiado e 5,6 balaios de 80 L sc^{-1} e em plantas de sequeiro, de 8,2 kg de café da roça/beneficiado; 3,1 kg de café coco/beneficiado e 12 balaios de 80 L sc^{-1}. A qualidade dos grãos do cafeeiro conilon obtidos em plantas irrigadas foi superior à de plantas de sequeiro. O consumo médio de água em plantas irrigadas foi de 7,9 m^3 e em sequeiro de 4,95 m^3. A relação entre o consumo de água/kg de café beneficiado foi de 8,8 m^3 e 30,3 m^3, em plantas irrigadas e de sequeiro. Não houve influência do tipo de recipiente e níveis de sombreamento na produtividade, rendimento e qualidade do cafeeiro conilon.

Termos para indexação: *Coffea canephora,* irrigação, produtividade, crescimento.

1 INTRODUCTION

The genus *Coffea* comprises at least 124 species, of which *Coffea arabica* L. and *C. canephora* Pierre ex A.Froehner are economically important (DAVIS et al., 2011). In the 2016 crop, world coffee production exceeded 155.0 million bags, of this total, about 35% is conilon coffee, produced in countries considered emerging, such as Brazil. Of the total coffee produced in the world, about 30% is in Brazil (INTERNATIONAL COFFEE ORGANIZATION, 2017). The state of Espírito Santo is the largest Brazilian coffee conilon producer, in 2016, production was 5.0 million bags, corresponding to 63% of Brazilian conilon coffee (CONAB, 2017).

The irrigation management strategy utilized must be efficient in conserving water without affecting the crop yield (BONOMO et al., 2013). Therefore, further studies are required to accurately estimate the water consumption of the coffee plant under different phenological phases, with the objective of improving the irrigation management (SILVA et al., 2008; SILVA et al., 2011). In fact, two reproductive stages of coffee can be harmed by droughts: flowering and fruiting (DAMATTA et al., 2007).

Even in traditional areas of coffee cultivation, irrigation is justified by the fact that they suffer most of the time the effect of prolonged droughts in the critical periods of water demand by

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coffee (VICENTE et al., 2015). The growth rate of orthotropic and plagiotropic branches of Conilon coffee, in the Atlantic Region of the State of Bahia, Brazil, was higher under irrigation compared to non-irrigated plants, with the result that irrigation has been used with and to increase production by eliminating the risk of water deficiency at critical stages of cultivation (COVRE et al, 2016). Irrigation also influences the growth and distribution of the root system of coffee, in plants irrigated by drip irrigation, a greater amount of roots occurs in the area comprised by the humid irrigation bulb (COVRE et al, 2015).

However, very few studies linking irrigation with coffee quality are presently available. Irrigation provides a steady supply of water that ensures the correct formation, granulation and filling of the grains, while preventing the emergence of pimples and poor-quality grains; it modifies the microclimate, as well. However, it also stimulates the rise in diseases like rust, and supports pests such as the coffee borer. These exert a negative influence on the final quality for raw coffee grain grading. The fruit size is also greatly affected by the water supplied to the plant, as the fruit becomes larger when the humidity is suitable, which in turn improves the final grain quality (REZENDE et al., 2010).However, apart from assessing production and quality, the crop yield must be determined; this refers to the quantity of coffee required to fill a 60 kg bag of coffee (LIMA; CUSTÓDIO; GOMES, 2008). In the end, beverage quality will determine the final commercial value of the coffee.

It is known that the production of healthy and vigorous seedlings is of paramount importance for the success of a coffee crop. Tatagiba et al. (2010) verified that young plants of Conilon coffee kept under 88% of shade recorded the highest values for total dry matter accumulation, followed by the level of 22 and 50%, while the seedlings maintained in full sun registered the lowest values, factor that can influence the production of a good coffee is the container. Several researches have been carried out with the objective of combining quality with cost reduction. Silva et al. (2010) found that the pressed block, bag and tube (120 mL) were the most suitable containers for the production of Conilon coffee seedlings, in which higher vegetative growth and more vigorous seedlings were obtained. However, studies that associate productive characteristics of Conilon coffee plantations with seedlings from different levels of shade or different containers are still scarce.

In light of the facts mentioned, the aim in this work was to assess and compare the yield, quality and water consumption of Conilon coffee subjected to irrigation and dryland management techniques, from seedlings raised in different containers and under various levels of shade.

2 MATERIAL AL AND METHODS

The experiment was performed at the IFES (Federal Institute of Education, Science and Technology of Espírito Santo), Alegre-ES Campus, Farm Caixa D'Água, Rive district, located at latitude 20º 25' 51.61" S and longitude of 41º 27' 24.51" W and altitude of 136,82 m, with 1,250 mm annual average precipitation and annual average temperature of 26 ° C. The plant species in the study was *C. canephora* , Tropical Robusta variety (EMCAPER 8151), through seed propagation.

Adopting the randomized complete block design, the experiment was carried out over 2 x 2 x 4 sub-divided plots. The plots, managed on two levels (irrigated and dry), in the subplots the container used in the formation of the seedlings also in other stages, (and bag); shading in sub-subplots was performed by seedling formation at four levels (0%, 30%, 50% and 75%), involving three replicates. Each experimental plot comprised three plants.

The seedlings raised in tubes (120 mL) and bags (770 mL) filled with standard substrate and subjected to different levels of shading, were planted on December 13, 2007. Plant spacing of 3.0 x 1.1 m was maintained and sowing done was in sandy-clay textured Yellow Red Latosol (LVA) (EMBRAPA, 2006). Correctives and chemical fertilizers were applied, depending on the chemical analysis of the soil, based on the parameters suggested in the Manual of Recommendation of Liming and Fertilization for Espirito Santo: 5th Approach (PREZOTTI et al., 2007). Suitable cultural and phytosanitary treatments were performed to meet the crop needs, incorporating the guidelines for Conilon coffee (FERRÃO et al., 2007).

The conventional sprinkler type of irrigation system was employed in the irrigated plot, in two lateral lines, each provided with two sectoral sprinklers, 18 m apart, the Christiansen's Uniformity Coefficient (CUC) was 80.6%, with average depth length of 13.68 mm. The direct irrigation method via the soil was used. Using an electric oven set at 180º to 200ºC temperature, the soil moisture was assessed from the samples collected at the projection of the crown having 40g minimum weight and including six replications, with the aid of a soil withdrawal probe, at different depths according to the age of the coffee tree. The irrigation depth (Li) needed to increase the soil moisture content (Ua) to field capacity (23.8%) was calculated by the following equation 1:

$$Li = [(CC-Ua) / 10] \times Ds \times Z \qquad \text{(Eq. 1)}$$

in which:
Li = Irrigation depth (IRN), in mm
CC = moisture in field capacity, % by weight
Ua = current soil moisture, wt%
Ds = soil density in g cm-3 (0-20 cm = 1.73; 20-40 cm = 1.63; and 0-35 cm = 1.68 g cm-3)
Z = effective depth of the root system, in cm (Z = 20 cm in the first year, Z = 25 cm from 1.0 to 2.0 years, Z = 30 cm from 2.0 to 2.5 years, Z = 35 cm from 2.5 years).

Precipitation was determined using a rain gauge fixed in the experimental region, of the Ville de Paris brand, with daily values being recorded at 9 o'clock. Effective precipitation was assessed using the difference between the total soil water capacity (CTA) and precipitation recorded in the irrigation interval (equation 2). Water consumption was calculated by taking into account the irrigation depths and effective precipitation per month, corresponding to the evaluation time periods given: from planting to the 1st harvest - (12/2007 to 04/2009 - from 0 to 17 months); 2nd harvest (05/2009 to 04 / 2010- from 18 to 28 months); 3rd harvest (05/2010 to 05 / 2011- from 29 to 40 months); 4th harvest (06/2011 to 05 / 2012- from 41 to 52 months).

$$CTA= [(CC-Pm) / 10] \times Ds \times Z \qquad \text{(Eq. 2)}$$

in which:
DTA = total soil water capacity, in mm
Pm = permanent wilting point, % by weight
Ds = soil density in g cm^{-3} (0-20 cm = 1.73; 20-40 cm = 1.63; and 0-35 cm = 1.68 g cm^{-3})
Z = effective depth of the root system, in cm (Z = 20 cm in the first year, Z = 25 cm from 1.0 to 2.0 years, Z = 30 cm from 2.0 to 2.5 years, Z = 35 cm from 2.5 years).

Adopting the criterion of at least 50% of ripe fruits, harvesting was done using the nonselective method, with manual sifting through sieves, followed by post-harvest processing utilizing the dry process, avoiding washing the fruits and then dried. The yield was evaluated by weighing the fruits harvested from each plant, to obtain the quantity of coffee produced by the field (CR pl^{-1}). From the total collection taken from the experimental plot, a 2-kg sample was drawn, and subjected to drying (coconut coffee - CC). Next, the coconut coffee sample was harvested and weighed. The values achieved in kg of coffee benefited per plant (CB pl^{-1}) were transformed, and adjusted and filled in bags of 60 kg ha-1 capacity. Post treatment, the moisture content of the beans on average was ± 12.0%, determined using GEHAGA G 600, version 7.3.

The yield was determined using the relationships between the kg weight of the CR per kg of CB; liters of CR per kg of CB; kg of coffee in CC per kg of CB (yield of the pile) and breakage (number of balloons of 80L per sc^{-1} of 60 kg of CB). From 300g of the sample, based the sieve dimensions, the classification was determined as numbers 10, 11 and 12 by coffee sieve size for the Mocha Grains, and numbers 13, 15 and 17 for the Flat Grains, based on the percentage of grains retained in the respective sieves, foundations and Mocha grains. Classification based on type was achieved by adding the defective numbers present in 100 g of the sample, following the Official Classification Table of Brazil, and through sampling, based on the standards set up by the Technical Regulations of Identity and Quality for the Classification of Raw Benefited Coffee (BRASIL, 2003).

The experimental data was submitted to statistical analysis, in which the means were compared by the F (ANOVA) and Tukey tests, at the 5% level of probability, through the SAEG 9.1 (2007) computer program.

3 RESULTS AND DISCUSSION

Figure 1 reveals that the total of the monthly precipitation during the agricultural years (2008 to 2012) was more than 1,250 mm, which is the annual average of the climatological norm from 1976 to 2011 (INCAPER, 2012). The rainy season extends from October to April, while the dry period lasts from May to September. The lowest monthly average rainfall during the rainy season was observed between January and February, the time when acute droughts might result in losses in the coffee yield, as it corresponds to the granulation stage of the coffee bean (CAMARGO, CAMARGO, 2001).

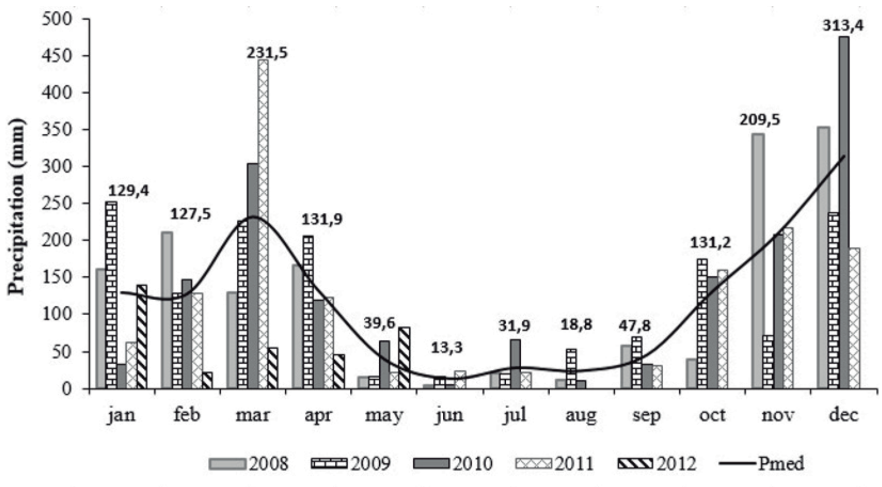


FIGURE 1 - Average monthly precipitation from 2008 to 2012; Alegre-ES.

According to Martins et al. (2015), water deficit and an air temperature are the meteorological elements that most influenced coffee productivity.

When the variations in the coffee production findings were submitted to the analysis of variance no interaction was noted among the factors and the study needed to be performed in isolation, as displayed in Table 1. However, during the harvest years (2010 and 2011), a noteworthy influence was seen for the management factor alone. Thus, it was concluded that neither the containers nor the levels of shading employed in seedling formation affected the benefited coffee production and, therefore, the harvest output during 2010/2011 / 2012 and yes the plant cultivation system. However, although the values recorded for the coefficients of variation of the variables in this work were notably high, between 33 and 47% magnitude, they fell within the acceptable range for experimentation with perennial crops. Ferrão et al. (2008) suggested that the higher coefficients of variation might be linked to sources like the long crop cycle, large size of the experiments, differentiated responses of the genotypes to high temperature and dry stress, and differentiated responses of the materials to the effects of pests and diseases, as well as winds and pruning.

Table 2 lists the productivity findings for the irrigated and rainfed Conilon coffee plants, assessed using the production of coffee benefited by the plant (Table 1). Only for the irrigated plants, the harvest was performed at 17 months, as the rainfed production was insignificant, analysis was not possible, and it was therefore disregarded for the evaluations of productivity, yield and quality. Karasawa et al. (2002), also reported that coffee plants lacking irrigation produced no grain during their first harvest.

The irrigated plants showed a higher yield than that of rainfed ones, less than 52 months in which no significant differences between the treatments were observed. For the irrigated plants, the yield obtained on average was 162% higher than that of the dryland plants, which translates to mean 23 bags more of the benefited coffee from 60 kg ha-^{1}. (Table 2). The results of several researchers indicated that irrigation promoted a profit of 20 to 30 bags ha^{-1} on average, notable among them being Gomes, Lima e Custódio (2007), Scalco et al. (2011) and Silva, Teodoro e Melo (2008). According to Leite Junior and Faria (2016) the lower the plant submission the water restriction, the greater the possibility of increases in coffee productivity. The national coffee industry typically experiences alternating high and low yields. This is largely due to the depletion of plant reserves during the high productivity season, causing the drop in the output during the following year. This phenomenon is clearly evident in the irrigated plants at 40 and 52 months. Faria and Siqueira (2005), as well as Silva, Teodoro and Melo (2008), similarly confirmed that irrigation did not minimize the biennial effect of productivity. They also showed that the irrigated *C. arabica* plants revealed lower productivity than the dryland variety, in the year just after a high harvest year. This ability of plants to recover after a period, often in abiotic stress conditions is due to their high resilience capacity, which is extremely important to ensure the acclimatization and sustainability of coffee production due to future scenarios of climate change (MARTINS et al., 2016; RODRIGUES et al., 2015).

TABLE 1 - Synthesis of analysis of variance and test of the means for the variable Conilon coffee production in kg of coffee benefited by plant, during the harvest years of 2010, 2011 and 2012.

Treatments	2010	2011	2012
Driving	486.07**	46.39**	3.7^{ns}
Irrigated	0.62 A	1.52 A	0.73 A
Dryland	0.07 B	0.19 B	0.84 A
Container	0.36^{ns}	2.23^{ns}	0.01^{ns}
Handling x Container	0.71^{ns}	0.11^{ns}	1.17^{ns}
Shading	0.86^{ns}	0.49^{ns}	0.59^{ns}
Shade x Handling	0.53^{ns}	1.70^{ns}	1.11^{ns}
Shade x Container	1.09^{ns}	0.41^{ns}	2.10^{ns}
Shade x Handling x Container	0.62^{ns}	0.38^{ns}	2.15^{ns}
CV (%)	39.45	33.85	47.08

** Significant at 1% probability by F test; ns - not significant by the F test; values followed by the same capital letter in the column do not differ from each other, at 5% probability, by Tukey test.

TABLE 2 - Conilon coffee productivity (sacks benefited from 60 kg ha^{-1}), from irrigated and rainfed plants, during four harvests (2009 to 2012).

Driving	Crops				
	2008/09 (17 months)	2009/10 (28 months)	2010/11 (40 months)	2011/12 (52 months)	Cumulative production
Irrigated	1.2	31.6 A	76.8 A	36.9 A	146.5
Dryland	0.0	3.6 B	9.6 B	42.7 A	55,9

Means followed by the same letter in the column do not differ from each other by the Tukey test, at the level of 5% probability.

Water is exclusively responsible for the higher yield obtained in the irrigated treatments, compared to that of the rainfed one. Thus, despite the annual rainfall of between 1,200 and 1,800 mm, which is within the optimal accepted range for the coffee plant, (Figure 1), typical summers in January / February were noted, particularly during the crop years of 2009/10 and 2010/11. This drought period tallied with the phenological stage characterized by the high water demand needed for the grain filling phase, which in turn resulted in the decline in yield of the rainfed plants cultivated in that period. This was verified because for the *C. arabica* and *C. canephora* plantations losses of productivity and lower grain quality were noted when the short dry seasons (*veranicos)* occurred during the critical phenological phases (SILVA et al., 2007; SILVA; TEODORO; MELO, 2008).

Productivity is as significant as grain yield, because poor yields will necessitate higher harvesting, drying and processing expenditures. When the crop yields at 28 and 40 months were analyzed, the irrigated plants showed values that exceeded those of the rainfed ones, and even at 52 months, although no statistical differences were observed between the yields (Table 2). For Conilon coffee, the weight ratio of the cherry fruits to the weight of coffee benefited is known to vary from 3.3 to 5.2: 1 and is contingent upon the genetic material; it increases at the time of harvesting the coffee plants, when they bear a greater percentage of green fruits (FERRÃO et al., 2007). For the irrigated plants, the average rates of coffee / coffee benefited and coffee / cocoa coffee ratio were recorded as being 4.5 and 1.9; and 5.6 balloons of 80 L sc^{-1} of 60 kg of coffee benefited. These results exhibited close similarity to those obtained in the *'Conilon Vitória'* variety (VITÓRIA INCAPER 8142), which recorded an average clone yield of 3.92 cherry / coffee beneficiated with a coconut/

benefited ratio of 1.8 (FERRÃO et al., 2007). For the rainfed plants, the mean indices noted were 8.2 for coffee / coffee ratio and 3.1 for coffee / coconut / coffee conversion; and 12 balloons of 80L sc-¹ of 60 kg of coffee benefited. According to Lima, Custódio e Gomes (2008), the non-irrigated *C. arabica* plants needed a more numbers of liters of coffee from the field to fill a 60 kg bag of coffee benefited (Table 3).

The dryland plants exhibited the lowest yield, which may be connected to the weight of 1000 grains, the average weight of which was 94 g over three harvests, while for the irrigated plants it was 108 g. Therefore, the insufficient rainfall distribution and paucity of water supplemented via irrigation might have contributed towards the pounding of the grains, as well as the greater percentage of poorly filled grains. This produces an intrinsic defect, leading to quality depreciation of the product and ultimately in low beneficiation yield.

Normally, for the irrigated seeds compared to the non-irrigated ones, a higher percentage of grains are retained in the sieves 13 and higher, which corresponds to higher coffee granulation in these treatments (Figure 2A). The irrigated plants showed values ranging from 65 to 93%, whereas in the rainfed ones, the range hovered from 40 to 88%. For the irrigated '*Conilon Vitória'* coffee variety Pereira (2015) reported 75.5% of the grains being retained in sieves 13 and higher and 40.5% for the non-irrigated plants. Rena and Maestri (2000) suggested that this occurred because the coffee bean size is determined between weeks 10 and 17, post flowering, when the fruit rapidly develops, with water being the factor solely responsible for the increase. Thus, the high percentages of the foundations recorded for the rainfed plants, referring to the grains that settle at the bottom after passing through the sieves, seem to contradict this affirmation (Figure 2B).

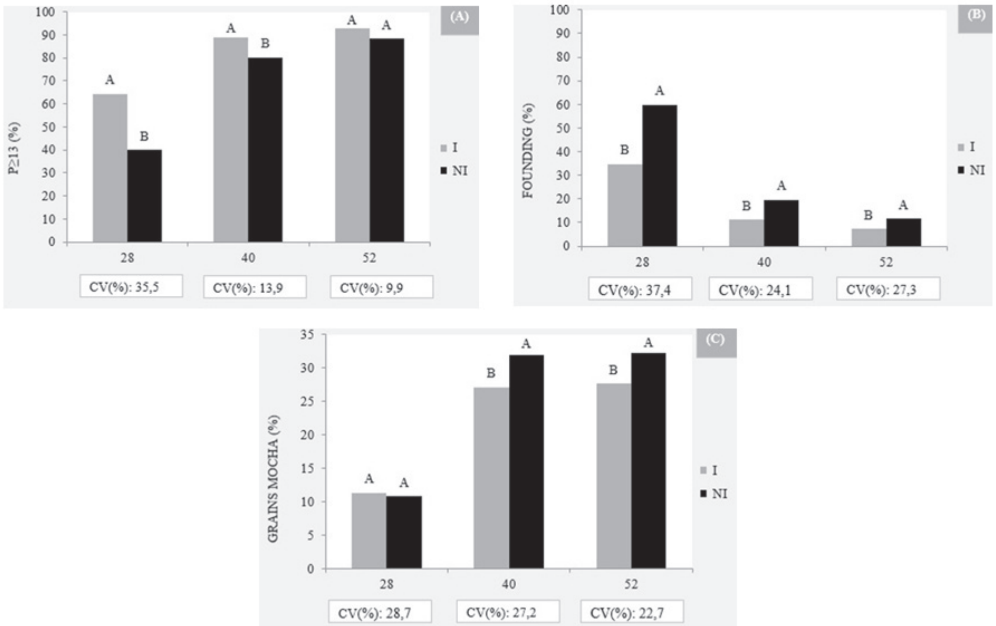
The Mocha type grain, promote lower yield when compared to those of the Flat type (flat-convex format). These grains are round in shape, having been formed from the development of a single seed, resulting from a gene abnormality (discoid endosperm) or environmental or physiological factors, including those of extended drought and nutrient deficiency (VACARELLI; MEDINA FILHO; FAZUOLI 2003). Figure 2C shows no statistical differences being recorded for the Mocha grains, between the treatments, at 28 months. However, at 40 and 52 months, the rainfed plants revealed values that surpassed those of the irrigated plants, as well as stayed higher than 21.4%, which was the mean value reported for the *'Conilon Vitória*' variety (FERRÃO et al., 2007).

Figures 3A and 3B indicate that at 28 and 40 months, the most number of defects were reported for the dryland management; they were classified as equivalence of types 7 and 6, based on the Brazilian Official Classification Table raw grain (BRASIL, 2003). The lesser equivalence in the number of defects for the irrigated management compared with the dryland coffee is due to the higher percentage of retention in sieves 13 and higher, which encouraged the beneficiation of the samples, producing lower quantities of broken grains, grains in shell *marinheiros* and bark, besides other aspects. At 52 months, no statistical differences were observed between the treatments, and the least numbers of defects were found and classified as type 5 and 4.

TABLE 3 - Yield, breakage and weight of 1,000 grains and percentage of low quality grains of Conilon coffee under irrigated and rainfed managements for three harvests (2010 to 2012).

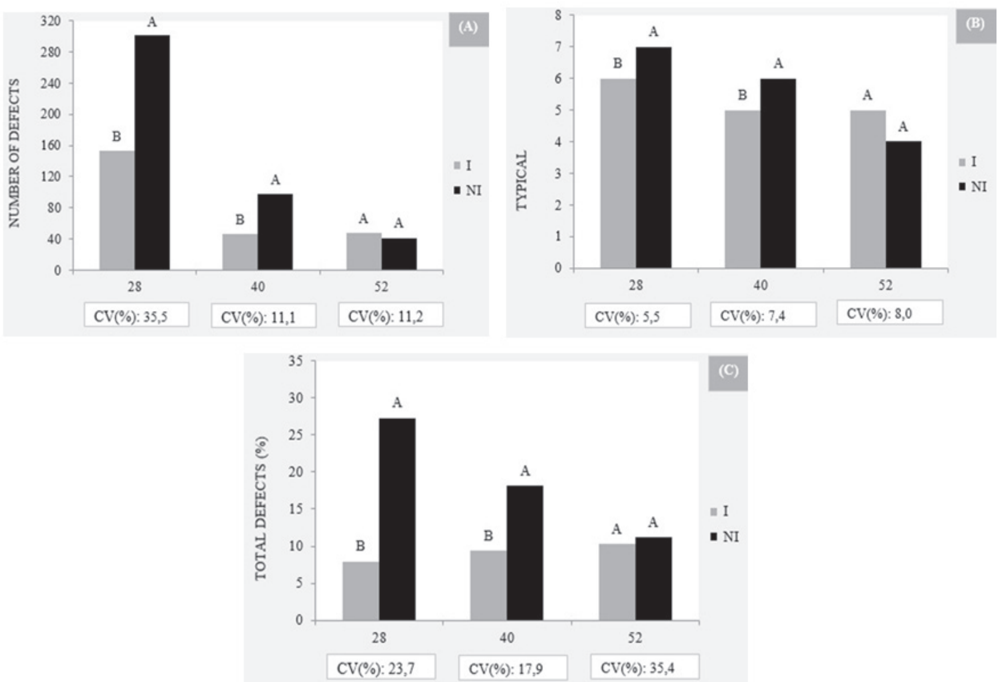
Indexes *	Relations	Harvests					
		28		40		52	
		I	NI	I	NI	I	NI
Yield	kgCR : kgCB	4,48	9,14	4,39	10,84	4,52	4,70
Stack yield	kgCC : kgCB	1,89	3,71	1,78	3,68	1,89	1,81
Breakage	NB 80L sc-¹	5,57	13,5	5,69	16,15	5,51	6,24
Weight of 1,000 grains	(g)	85,21	66,36	116,5	96,57	122,3	119,21
Percentage of low quality grains	(%)	1,5	9,7	3,0	9,0	1,54	5,02

* Yield: kgCR: kgCB- kg of coffee per kg of coffee benefited (CB); stack yield: kg Cc: kgCB - kg of coconut coffee per kg of CB; breakage: NB 80L sc^{-1} - number of balloons of 80L per sc of 60 kg of CB.



Means followed by the same letters do not differ from each other by the Tukey test, at the 5% probability level.

FIGURE 2 - Retention in sieve 13 and higher (P≥13), founding and percentage of coffee beans in Conilon under irrigated and rainfed management methods, during three harvests (2010 to 2012).



Means followed by the same letters do not differ from each other by the Tukey test, at the 5% probability level.

FIGURE 3- Classification by type, number of defects and total defects by weight for the Conilon coffee crop under irrigated and rainfed management methods, during three harvests (2010 to 2012).

Therefore, positive results for the number of defects may be linked (at least 50% of mature fruits), as well as to the care given during the fruit drying stages, which can be confirmed by the results total defects (Figure 3C). In this case the higher the percentage of total defects, the greater the problems in coffee quality. Thus, on average values of 9.2% and 18.9% were obtained respectively, for the irrigated and dry coffee plant harvests.

With respect to the irrigation depth (Li), the smallest leaf applied is consistent with the crop formation stage (17 months), largely because of the high incidence of precipitation. The next two productive periods (18 to 52 months), saw a decline in the values of the effective precipitation and the irrigation depth showed an increase as the crop developed (Figure 4). This concurs with the claims of Lena, Faria e Flumignan (2011), who stated that the water utilized by the coffee plants during the initial developmental phase was due to climatic variations, the greater exposure of the soil and small leaf area. However, the rise in the water consumption rates from the flowering stage to the commencement of grain filling resulted mostly from the large leaf area of the plants.

From Figures 5A and 5B, it is evident that the water consumed per plant and its relation with the production of coffee benefited, during the different growth phases and managements are higher for the irrigated plants than those for the rainfed plants, whose average values corresponded to 7.86 m³ and 4.95 m³, respectively. However, when this consumption was related to the production of coffee benefited (Figure 5B), the irrigated plants revealed an average value of 8.8 m3 of water kg-1 of coffee benefited, while the rainfed plants registered a value of 30.3 m3 of water kg-1 of coffee benefited. However, the low values seen for the rainfed plants at 52 months are noteworthy, and are due to their higher productivity in this cropping system. When the results of the research are adjusted according to the work of Bonomo et al. (2014), the water consumption on average of the Conilon coffee clones during the productive phase, while maintaining the soil water balance through irrigation, was 8.22 m³ which corresponded to 6.58 m³ of water per kg of coffee benefited. Thus, the water consumption observed for Conilon coffee is related to the phenological cycle, plant age, incident precipitation and production, besides irrigation management (Figure 5).

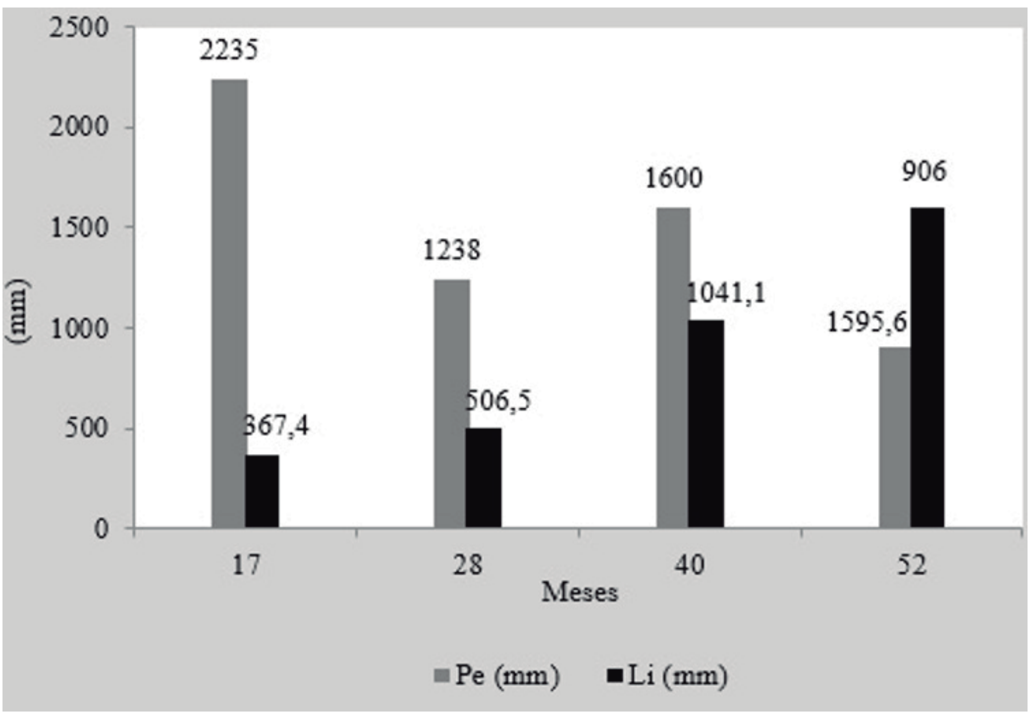
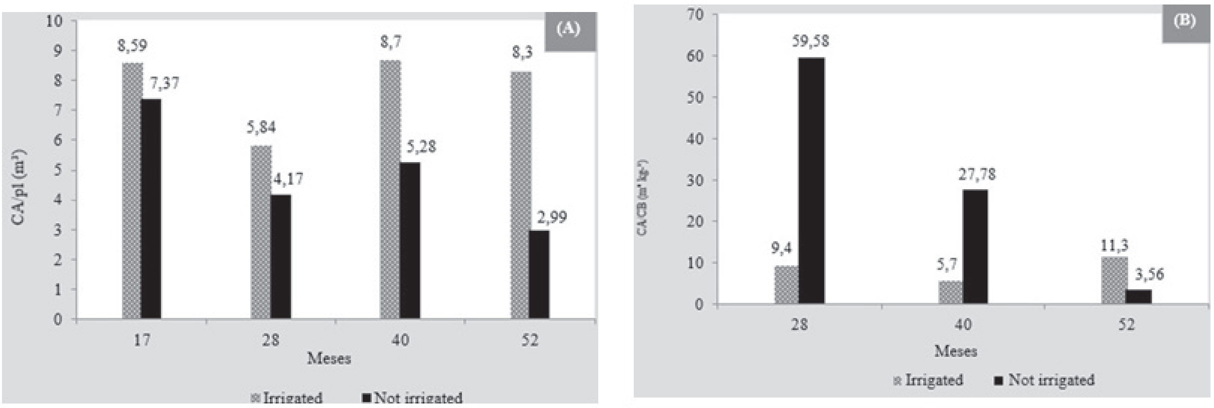


FIGURE 4 - Effective precipitation (Pe) and irrigation depth (Li) utilized for irrigation of the Conilon coffee plants during the different developmental phases.



* 17 months (Jan / 08 to April / 09); 28 months (May / 09 to April / 10); 40 months (May / 10 to April / 11); 52 months (May / 11 to April / 12).

FIGURE 5 - Water consumption per plant (CA / pl) and the relation between the water consumed and coffee benefited (CA / CB) of the irrigated and rainfed Conilon coffee plants at different developmental stages.

4 CONCLUSIONS

The irrigated Conilon coffee plants revealed higher productivity and yield, as well as better grain quality than those from the rainfed ones.

Irrigation management induced higher water consumption per plant and lower consumption per kilogram of coffee benefited.

The container and levels of shading employed in the raising the seedlings did not affect the Conilon coffee in terms of productivity, yield and quality.

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