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Comparison between grafting and cutting as vegetative propagation methods for conilon coffee plants

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ABSTRACT. The purpose of this study was to assess the growth of conilon coffee tree plantlets that were propagated by grafting and cutting. The experiment was conducted at the plantlet production site of Incaper's Experimental Farm in the city of Marilândia, Espírito Santo State. For grafting, plantlets derived from the seed propagation of *Coffea canephora* cv. Robusta Tropical (ENCAPER 8151) were used as rootstocks, and six clones of cv. Conilon Vitória (INCAPER 8142) were used as the grafts. The cutting was performed with six clones that were used for grafting. The experimental design consisted of randomized blocks of twelve treatments with five repetitions composed of twelve plantlets. On the hundred and fifth day, the averages of the variables were assessed and compared by the Scheffé test at a probability of 5%. The grafted plantlets were superior for almost all of the characteristics assessed, which suggests that it is possible to propagate conilon coffee trees.

Keywords: *Coffea canephora*, coffee, growth, cloning.

Comparação entre enxertia e estaquia como métodos de propagação vegetativa de plantas de café conilon

RESUMO. Objetivou-se avaliar o crescimento de mudas propagadas por enxertia e por estaquia no cafeeiro Conilon. O experimento foi conduzido no viveiro de produção de mudas da Fazenda Experimental do Incaper, no município de Marilândia, Estado do Espírito Santo. Na enxertia utilizou-se como porta-enxerto, mudas provenientes de propagação seminífera, da espécie *Coffea canephora*, cv. Robusta Tropical (ENCAPER 8151), e como enxerto, seis clones do cv. Conilon Vitória (INCAPER 8142). A estaquia foi realizada com seis clones usados na enxertia. O delineamento experimental foi em blocos casualizados com doze tratamento e cinco repetições composta de doze mudas. Aos 150 dias avaliou-se as médias das variáveis, que foram comparadas pelo teste de Scheffé a 5% de probabilidade. Detectou-se superioridade para as mudas enxertadas em quase todas as características avaliadas, sendo, portanto mais uma possibilidade para a propagação do cafeeiro conilon.

Palavras-chave: *Coffea canephora*, café, crescimento, clonagem.

Introduction

Approximately 100 species of the genus *Coffea* have been described (DAVIS et al., 2006), of which only two, *C. arabica* (arabian coffee) and *C. canephora* (Robusta coffee), are economically exploited. In Brazil, almost all of the varieties grown are *C. canephora* cv. Conilon, which is better known as Robusta coffee (BRAGANÇA et al., 2001). Espírito Santo is the largest national producer of this variety (CONAB, 2012).

The 'Conilon' coffee tree is diploid with 2n = 22 chromosomes and self-incompatible, reproducing by crossed fertilization. This incompatibility is gametophytic (CONAGIN; MENDES, 1961; BERTHAUD, 1980). Because it is allogamous, it promotes differentiations in plant height, vegetative vigor, size, color and fruit shape (FERREIRA et al., 2005). Thus, when selecting progeny of the 'Conilon' coffee tree, genetic divergence studies, which take into account various characteristics including productivity, must be performed (FERREIRA et al., 2005; CECON et al., 2008; FERRÃO et al., 2008; NIKHILA et al., 2008; KITILA et al., 2011).

To ensure the permanence of specific characteristics of each genotype of the *C. canephora* coffee tree, cutting is used as a means of propagation (WEIGEL; JURGENS, 2002; PARTELLI et al., 2006b), creating populations of elite clones with desirable agronomic features

including precocity, productive stability, architecture uniformity, higher productivity, fruit quality, and escalated cropping. The possibility of independent multiplication regardless of the time of the year was one of the fundamental factors to consolidate this technology; in addition, plants propagated through cutting exhibit higher productivity than plants propagated by seeds (JUNQUEIRA et al., 2006; PARTELLI et al., 2006b).

Although there are gains obtained through the planting of clones, problems that arise from the genetic narrowing of the species and shallower radicular systems can be observed in the field. A few clones in the field have shown allometric growth, exhibiting uneven relationships between their aerial parts and radicular systems and in many cases resulting in the death of the plants. Bragança et al. (2010) observed sigmoidal growth for conilon coffee where there is no balance between the foliar area and the total biomass of the plant.

Within the context of aiming to balance plant growth and ensure the permanence of the features obtained by vegetative propagation, grafting is a precise tool for adding a radicular system that has originated through sexual reproduction. Grafting effectively enables a new balancing of the plant's biomass with quick results in arabian coffee beans (OLIVEIRA et al., 2004), contributing to increased productivity (FAHL et al., 1998).

Thus, the purpose of the present study was to assess the growth of conilon coffee plantlets produced by grafting and cutting.

Material and methods

This experiment was conducted at the plantlet production site of the Incaper Experimental Farm in the city of Marilândia, Espírito Santo State, which is located at an altitude of 102 m, a latitude of 19°24'25" South and a longitude of 40°32'20" West. The climate classification proposed by Köppen is tropical moist with an annual average temperature of 24°C (FEITOSA et al., 1999).

Plantlets derived from the seed propagation of *C. canephora* cv. Robusta Tropical (ENCAPER 8151) were used as rootstocks and 13 clones of cv. Conilon Vitória (INCAPER 8142) were used for grafting (FERRÃO et al., 2007). Grafting was performed after selecting six diverging precocious (8 and 12v), average (2 and 7v) and late (5 and 13v) clones.

Seeding was performed directly into plastic bags. The plantlets were separated by two-centimeter bamboo rulers to increase the collection diameter more quickly. The planting mixture that was employed was composed of 70% underground earth and 30% coffee straw; for each cubic meter, 2 kg of dolomitic limestone, 5 kg of simple super phosphate and 1 kg of potassium chloride were added (PREZOTTI et al., 2007). This standard mixture is still widely used in the production of coffee plantlets due to its chemical composition and easily purchasable components (DIAS; MELO, 2009).

An analysis of the mixture was performed after it was evenly combined, and it was verified to be at pH 6.0. It contained 1.1 dag kg^{-1} of organic matter and 550, 31.4, 56, 40, 1.7 and 49 mg dm^{-3} of K, Zn, Fe, Mn, Cu and B, respectively. The concentrations of Ca, Mg, Al, H+Al and CTC (t) were 5.4, 1.1, 0.0, 1.4, 7.9 and 7.9 $cmol_c$ dm^{-3}, respectively, and 85% of bases were saturated.

The forking, filled gap mode method of grafting was employed and was performed 90 days after the seeding of 'Robusta Tropical' when the plantlets already presented a diameter that was compatible with the grafts. Concomitant with the grafting process, the planting of the rootstocks of the precocious (8 and 12v), average (2 and 7v) and late (5 and 13v) maturation 'Conilon Vitória' clones was performed.

The plantlets, after being grafted to the ones derived from cutting, were stored under a 50% shading roof with an intermittent nebulization irrigation system to ensure proper conditions of light and moisture for their growth.

When the plantlets had two pairs of leaves, they were individually identified and grouped in blocks under a palm tree cover; the cover was later removed slowly until full sunlight was achieved to ensure that they were ready for definitive planting 150 days after grafting.

When the plantlets were under controlled climate conditions, their assessments were performed. Plant height (cm) was measured using a millimeter-graded ruler; stem diameter was measured with the aid of a digital caliper; foliar area (cm^2) was measured with the (Licor Inc., Lincon, Nebrasca, US), model LI-COR LI-3000 the radicular system volume (mL) was measured with a graduated cylinder; and masses of the fresh matter of the leaves (g), stems (g), stem of the primary graft (g), roots (g) and final roots (g) and the total fresh matter (g) were quantified using an Ohaus Adventurer™ model ARD 110 digital scale with a precision of two decimal places.

The relationship between the mass of the dry matter of the aerial parts and the dry matter of the root, the RPAR, and the relationship between the height of the aerial parts and their diameter, the

RAD, were collected. The Dickson quality index (DQI), obtained by the equation [total dry matter mass/(RAD+RPAR)] (DICKSON et al., 1960), was verified. To determine the mass of the dry matter of the leaves (g), stems (g), primary graft stems (g) and roots (g), these structures were collected individually dully individualized, placed in labeled paper bags and subsequently conditioned in a forced circulation chamber at 70ºC for 72 hours until they achieved a constant weight.

The experimental design consisted of randomized blocks of twelve treatments and five plots, each composed of twelve plantlets. The averages of the treatments were submitted to an analysis of variance. If significant differences were detected between the treatments, the averages were compared using the Scheffé test at a probability of 5% (STEEL et al., 1997), which compared the grafting and grafted treatment groups. In an attempt to investigate which propagated material was superior in growth or which material would exhibit unsatisfactory growth, thus indicating a potential incompatibility between the graft and the rootstock, the Scheffé test was performed within the cloned and grafted groups and also by a joint comparison of the precocious (8 and 12v), average (2 and 7v) and late (5 and 13v) maturation degrees.

All of the analyses were performed with the assistance of the GENES (CRUZ, 2013) computer program.

Results and discussion

Thirty days after grafting, all of the plantlets exhibited welding in the grafted area, and when a randomly chosen plantlet was lifted using the graft, it was able to support its own weight showing a strong connection with the rootstock. Such observations agree with Dickson (2000), who stated that welding occurs within a few days; in this initial stage, there is a formation of parenchymal cells at the graft's interface, which fills the gap at the grafting spot through hardening and promotes the junction of the graft with the rootstock.

Grafting resulted in junctions 91.5% of the time and demonstrated promise as a method for the propagation of conilon coffee plants, whereas the traditional cutting system resulted in junctions 96.8% of the time.

The grafted plantlet was determined to be superior if it was comparable to the cutting for the following characteristics: foliar area; leaf, stem, primary graft stem, aerial parts, root and total fresh matter masses; root volume; the number of leaves; plant height; the relationship between plant height and stem diameter; and the Dickson quality index. For the stem diameter, no significant difference was detected between the cloned and grafted groups. For the relationship between the dry matter mass of the aerial parts and the dry matter mass of the root, the averages of the cloned group were greater than the averages of the grafted group as shown in Table 1.

Table 1. Averages of the foliar area variables (FA), fresh leaf matter mass (FLMM), dry leaf matter mass (DLMM), fresh stem matter mass (FSMM), dry stem matter mass (DSMM), primary graft stem fresh matter mass (PGSFMM), primary graft stem dry matter mass (PGSDMM), aerial parts fresh matter mass (APFMM), aerial parts dry matter mass (APDMM), fresh root matter mass (FRMM), dry root matter mass (DRMM), thin root dry matter mass (TRDMM), root volume (RV), total fresh matter mass (TFMM), total dry matter mass (TDMM), the number of leaves (NL), plant height (PH), stem diameter (SD), the relationship between plant height and stem diameter (HDR), the relationship between the aerial parts dry matter mass and the root dry matter mass (APRR) and the Dickson quality index (DQI) for the grafting and cutting propagation methods$_{(1)}$.

Variables	Propagation methods		$\lvert \hat{C}_i \rvert$	S the 5%
	Grafting	Cutting		
FA (cm^2)	187.400	298.700	-111.4	26.680*
FLMM (g)	4.864	7.439	-2.575	0.725*
DLMM (g)	1.230	1.988	-0.758	0.225*
FSMM (g)	3.583	6.238	-2.655	0.427*
DSMM (g)	1.037	2.096	-1.059	0.165*
PGSFMM (g)	2.154	3.800	-1.646	0.241*
PGSDMM (g)	0.705	1.490	-0.786	0.103*
APFMM (g)	8.448	13.670	-5.230	1.076*
APDMM (g)	2.268	4.085	-1.817	0.369*
FRMM (g)	3.466	7.604	-4.138	1.487*
DRMM (g)	0.822	2.149	-1.328	0.220*
TRDMM (g)	0.339	0.870	-0.530	0.135*
RV (cm^3)	3.550	7.248	-3.698	1.444*
TFMM (g)	11.910	21.283	-9.369	2.031*
TDMM (g)	3.089	6.234	-3.145	0.564*
NL	9.481	10.940	-1.457	1.064*
PH (cm)	6.710	9.475	-2.765	1.145*
SD (mm)	3.171	3.324	-0.153	0.196^{ns}
HDR	2.122	2.859	-0.737	0.378*
APRR	2.774	1.913	0.861	0.195*
DQI	0.633	1.323	-0.689	0.148*

$_{(1)}$ ^{ns}indicates non-significant and * indicates significant differences when the grafting and cutting propagation methods are compared with the Scheffé test at a probability of 5%.

The superior results of grafting propagation when compared with cloned propagation can be explained by the following fact: at the moment of grafting on day 90, there is already a rootstock radicular system that has exhibited satisfactory growth. Thus, it is possible that the entire reserve of the graft was directed to produce biomass for the aerial parts, ensuring their expressive growth against the same clone materials. Other authors (FAHL et al., 1998; TOMAZ et al., 2006, 2008) that have studied the effects of the *C. canephora* rootstock on the growth of grafts of *C. arabica* observed an increased growth of the aerial parts, longer radicular lengths and larger volumes even when Catuaí Vermelho IAC 15 was combined with rootstocks 'ES26' and 'ES23', which were effective and produced dry matter when magnesium was applied.

The influence of the radicular system on the plant's growth and tolerance to environmental stress has become evident with the use of the reciprocal grafting technique (HARTMANN et al., 2002). For example, it was verified that grafting dry-sensitive materials with rootstocks that are tolerant to dry environments results in an increased tolerance to dryness and the effective use of water by sensitive plants (SILVA et al., 2010).

The grafted plantlets exhibited better results for all of the radicular system variables when compared with the same genotypes propagated by cutting (Table 1). The rhizogenic process resulted in a greater thin root dry matter mass in grafted plantlets (0.87 g) when compared with the plantlets propagated by cutting (0.44 g). This feature is fundamental for the initial growth of the plantlets because it ensures a higher efficiency of water and nutrient absorption (HARMAND et al., 2004), and according to Laclau et al. (2001), the spatial distribution of some roots determines their high capacity for nutrient absorption. However, robust plantlets that exhibit a higher percentage of root emission are better able to withstand environmental stress conditions, ensuring higher post-planting survival rates (FREITAS et al., 2005).

The root volume varied between the grafted materials (7.24 cm^3) and the plantlets propagated by cutting (3.55 cm^3), which can be partially explained by the characteristic of the roots derived from seed propagation. It may also be an indication of higher exploitation of the radicular system. The main physiological mechanisms of differential tolerance to dryness among the 'Conilon' genotypes are already known; these mechanisms are governed by the effective extraction of water from the ground and by the water usage rates of the plants (DAMATTA et al., 2003; PINHEIRO et al., 2005; DAMATTA; RAMALHO, 2006). Thus, grafted plants can be more adaptable to adverse field conditions after they have developed a larger radicular system.

To perform agronomic and physiological studies involving vegetal growth, it is necessary to know the characteristics of the aerial parts of the plant because the leaf is the location of the synthesis of photo-assimilated elements that are important for root growth (BLANCO; FOLEGATTI, 2003); the foliar area is one of the most important of these characteristics (FAVARIN et al., 2002; PARTELLI et al., 2006a).

Table 2 shows the characteristics of the aerial parts, such as foliar area, the number of leaves, and the dry matter masses of the leaf and aerial parts that were presented for grafting. They are related to a higher luminous absorption surface, which results in a carbon fixation gain by the plant; that is, a higher foliar area gives the plant a greater capacity to produce and store photo-assimilated elements. These observations support results obtained by Pauletto et al. (2001), Hartmann et al. (2002), who stated that factors which govern the absorption and translocation of water, nutrients and endogenous substances favor the growth of the aerial parts.

Understanding growth characteristics and their interactions will determine how close are to the ideal plantlet production. In this sense, stem diameter, plant height and the relationship between stem diameter and plant height varied between the grafting and cutting propagation systems, from 3.17 to 3.32 mm, 6.7 to 9.5 cm and 2.1 to 2.8, respectively. Stem diameter was the only variable that did not exhibit a difference as shown in Table 1. Similar values were obtained by Marana et al. (2008) for *C. arabica*. One of the important characteristics that determines the quality of the plantlet is the collection diameter, which represents a 10.4% contribution, and has the advantage of not being a destructive method (GOMES et al., 2002). According to Zonta et al. (2009), lower collection diameters are associated with longer watering shifts. The shoot height and diameter are easy to measure, non-destructive and technically accepted as a good measure of the performance potential of seedlings. The resulting index of the relationship between shoot height and stem diameter expresses the balance of growth, also called the robustness quotient, and is considered to be one of the most accurate indexes because it provides information on how thin the seedlings are.

The Dickson quality index is a well-established morphological measure. It is a good standard measure of plantlet quality because its calculation

takes the robustness and distribution balance of the biomass into account, and it also assesses various important morphological characteristics (DICKSON et al., 1960). The present study found values of 0.63 for cutting propagations and 1.32 for grafting propagations. According to Dickson et al. (1960), the higher the value, the better the quality of the plantlets. In this case, quality indicates a better balance between the shoot and root systems, resulting in more seedlings adapted to the harsh conditions of the field, which ensures lower rates of death after planting.

Non-significant interactions were observed for both grafting and cutting among the precocious, average and later maturation season groups for all characteristics assessed on Tables 2 and 3, except for the foliar area in Table 2. The significant interactions between the precocious and average groups within the cutting treatment may have occurred because materials 8v and 12v were more vigorous, which was highlighted in the plantlet production. It implies vigorous seedlings that in the field adapted better to the adverse conditions of climate and soil.

Table 2. Averages of the foliar area variables (FA), fresh leaf matter mass (FLMM), dry leaf matter mass (DLMM), fresh stem matter mass (FSMM), dry stem matter mass (DSMM), primary graft stem fresh matter mass (PGSFMM), primary graft stem dry matter mass (PGSDMM), aerial parts fresh matter mass (APFMM), aerial parts dry matter mass (APDMM), fresh root matter mass (FRMM), dry root matter mass (DRMM), thin root dry matter mass (TRDMM), root volume (RV), total fresh matter mass (TFMM), total dry matter mass (TDMM), the number of leaves (NL), plant height (PH), stem diameter (SD), the relationship between plant height and stem diameter (HDR), the relationship between the aerial parts dry matter mass and the root dry matter mass (APRR) and the Dickson quality index (DQI) for plants propagated by the cutting method. A joint comparison was performed among the precocious (8 and 12v), average (2 and 7v) and late (5 and 13v) maturation groups$_{(1)}$.

Variables	Cutting			$\lvert \hat{C}_i \rvert$	S the 5%
	Maturation season				
	Precocious	Average	Late		
FA (cm^2)	205.546	158.021	-	47.519	46.216*
FLMM (g)	5.222	4.099	-	1.122	1.256^{ns}
DLMM (g)	1.346	1.039	-	0.307	0.390^{ns}
FSMM (g)	3.830	3.281	-	0.549	0.740^{ns}
DSMM (g)	1.109	0.939	-	0.170	0.285^{ns}
PGSFMM (g)	2.355	2.047	-	0.307	0.419^{ns}
PGSDMM (g)	0.755	0.661	-	0.095	0.179^{ns}
APFMM (g)	9.052	7.381	-	1.671	1.864^{ns}
APDMM (g)	2.455	1.978	-	0.476	0.639^{ns}
FRMM (g)	3.683	3.082	-	0.601	2.576^{ns}
DRMM (g)	0.861	0.769	-	0.092	0.381^{ns}
TRDMM (g)	0.371	0.312	-	0.059	0.235^{ns}
RV (cm^3)	3.666	3.017	-	0.649	2.501^{ns}
TFMM (g)	12.735	10.463	-	2.272	3.518^{ns}
TDMM (g)	3.316	2.747	-	0.569	0.977^{ns}
NL	10.150	8.650	-	1.500	1.843^{ns}
PH (cm)	6.918	6.137	-	0.781	1.983^{ns}
SD (mm)	3.304	3.110	-	0.194	0.339^{ns}
HDR	2.095	1.986	-	0.109	0.654^{ns}
APRR	2.845	2.639	-	0.206	0.338^{ns}
DQI	0.667	0.605	-	0.062	0.257^{ns}
FA (cm^2)	205.546	-	198.549	6.996	46.216^{ns}
FLMM (g)	5.222	-	5.273	-0.051	1.257^{ns}
DLMM (g)	1.346	-	1.306	0.039	0.391^{ns}
FSMM (g)	3.830	-	3.639	0.192	0.740^{ns}
DSMM (g)	1.109	-	1.063	0.046	0.285^{ns}
PGSFMM (g)	2.355	-	2.063	0.292	0.419^{ns}
PGSDMM (g)	0.756	-	0.698	0.057	0.179^{ns}
APFMM (g)	9.052	-	8.912	0.140	1.864^{ns}
APDMM (g)	2.455	-	2.369	0.085	0.639^{ns}
FRMM (g)	3.683	-	3.634	0.049	2.576^{ns}
DRMM (g)	0.861	-	0.835	0.026	0.381^{ns}
TRDMM (g)	0.371	-	0.336	0.035	0.235^{ns}
RV (cm^3)	3.666	-	3.967	-0.301	2.501^{ns}
TFMM (g)	12.735	-	12.545	0.190	3.518^{ns}
TDMM (g)	3.316	-	3.205	0.111	0.977^{ns}
NL	10.150	-	9.644	0.506	1.843^{ns}
PH (cm)	6.918	-	7.077	-0.159	1.983^{ns}
SD (mm)	3.304	-	3.098	0.206	0.339^{ns}
HDR	2.095	-	2.285	-0.190	0.654^{ns}
APRR	2.845	-	2.838	0.007	0.338^{ns}
DQI	0.667	-	0.628	0.039	0.257^{ns}
FA (cm^2)	-	158.026	198.549	-40.523	46.216^{ns}
FLMM (g)	-	4.099	5.273	-1.173	1.257^{ns}
DLMM (g)	-	1.039	1.306	-0.267	0.391^{ns}
FSMM (g)	-	3.281	3.638	-0.357	0.740^{ns}
DSMM (g)	-	0.939	1.063	-0.124	0.285ns

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Variables	Cutting			$\lvert \hat{C}_i \rvert$	S the 5%
	Maturation season				
	Precocious	Average	Late		
PGSFMM (g)	-	2.047	2.063	-0.015	0.419^{ns}
PGSDMM (g)	-	0.661	0.698	-0.037	0.179^{ns}
APFMM (g)	-	7.381	8.912	-1.531	1.864^{ns}
APDMM (g)	-	1.978	2.369	-0.391	0.639^{ns}
FRMM (g)	-	3.082	3.634	-0.552	2.576^{ns}
DRMM (g)	-	0.769	0.835	-0.066	0.381^{ns}
TRDMM (g)	-	0.312	0.336	-0.024	0.235^{ns}
RV (cm^3)	-	3.017	3.967	-0.950	2.501^{ns}
TFMM (g)	-	10.460	12.545	-2.082	3.518^{ns}
TDMM (g)	-	2.747	3.205	-0.458	0.978^{ns}
NL	-	8.650	9.644	-0.994	1.843^{ns}
PH (cm)	-	6.137	7.077	-0.940	1.983^{ns}
SD (mm)	-	3.110	3.098	0.012	0.339^{ns}
HDR	-	1.986	2.285	-0.299	0.654^{ns}
APRR	-	2.639	2.838	-0.199	0.338^{ns}
DQI	-	0.605	0.628	-0.023	0.257^{ns}

$_{(1)}$ ^{ns} indicates non-significant and * indicates significant differences when comparisons are made within the cutting propagation method by the Scheffé test at a probability of 5%; the precocious, average and late maturation times were taken into account.

Table 3. Averages of the foliar area variables (FA), fresh leaf matter mass (FLMM), dry leaf matter mass (DLMM), fresh stem matter mass (FSMM), dry stem matter mass (DSMM), primary graft stem fresh matter mass (PGSFMM), primary graft stem dry matter mass (PGSDMM), aerial parts fresh matter mass (APFMM), aerial parts dry matter mass (APDMM), fresh root matter mass (FRMM), dry root matter mass (DRMM), thin root dry matter mass (TRDMM), root volume (RV), total fresh matter mass (TFMM), total dry matter mass (TDMM), the number of leaves (NL), plant height (PH), stem diameter (SD), the relationship between plant height and stem diameter (HDR), the relationship between the aerial parts dry matter mass and the root dry matter mass (APRR) and the Dickson quality index (DQI) for plants that were propagated by the grafting method. A joint comparison was performed among the precocious (8 and 12v), average (2 and 7v) and late (5 and 13v) maturation groups$_{(1).}$

Variables	Grafting			$\lvert \hat{C}_i \rvert$	S the 5%
	Maturation season				
	Precocious	Average	Late		
FA (cm^2)	292.817	305.369	-	-12.552	46.216^{ns}
FLMM (g)	7.569	7.324	-	0.245	1.257^{ns}
DLMM (g)	2.025	1.936	-	0.089	0.391^{ns}
FSMM (g)	6.242	6.159	-	0.083	0.740^{ns}
DSMM (g)	2.110	2.058	-	0.052	0.285^{ns}
PGSFMM (g)	3.865	3.618	-	0.247	0.419^{ns}
PGSDMM (g)	1.515	1.437	-	0.078	0.179^{ns}
APFMM (g)	13.812	13.483	-	0.329	1.864^{ns}
APDMM (g)	4.135	3.994	-	0.141	0.639^{ns}
FRMM (g)	7.601	7.723	-	-0.122	2.576^{ns}
DRMM (g)	2.253	2.001	-	0.252	0.381^{ns}
TRDMM (g)	0.923	0.832	-	0.091	0.235^{ns}
RV (cm^3)	7.326	7.300	-	0.026	2.501^{ns}
TFMM (g)	21.413	21.205	-	0.208	3.518^{ns}
TDMM (g)	6.388	5.995	-	0.393	0.978^{ns}
NL	11.610	9.988	-	1.622	1.843^{ns}
PH (cm)	9.028	10.289	-	-1.261	1.983^{ns}
SD (mm)	3.380	3.323	-	0.057	0.339^{ns}
HDR	2.676	3.108	-	-0.432	0.654^{ns}
APRR	1.839	2.007	-	-0.168	0.338^{ns}
DQI	1.42	1.183	-	0.237	0.257^{ns}
FA (cm^2)	292.817	-	298.041	-5.224	46.216^{ns}
FLMM (g)	7.569	-	7.425	0.144	1.257^{ns}
DLMM (g)	2.025	-	2.004	0.021	0.391^{ns}
FSMM (g)	6.242	-	6.316	-0.073	0.740^{ns}
DSMM (g)	2.110	-	2.122	-0.011	0.285^{ns}
PGSFMM (g)	3.865	-	3.919	-0.054	0.419^{ns}
PGSDMM (g)	1.515	-	1.519	-0.003	0.179^{ns}
APFMM (g)	13.812	-	13.741	0.071	1.864^{ns}
APDMM (g)	4.135	-	4.125	0.010	0.639^{ns}
FRMM (g)	7.601	-	7.489	0.112	2.576^{ns}
DRMM (g)	2.253	-	2.195	0.058	0.381^{ns}
TRDMM (g)	0.923	-	0.855	0.068	0.235^{ns}
RV (cm^3)	7.326	-	7.117	0.209	2.501^{ns}
TFMM (g)	21.413	-	21.231	0.182	3.518^{ns}
TDMM (g)	6.388	-	6.321	0.067	0.978^{ns}
NL	11.610	-	11.216	0.394	1.843^{ns}
PH (cm)	9.028	-	9.109	-0.081	1.983^{ns}
SD (mm)	3.380	-	3.268	0.112	0.339^{ns}
HDR	2.676	-	2.793	-0.117	0.654^{ns}
APRR	1.839	-	1.892	-0.053	0.338^{ns}

Continue...

...Continuation

Variables	Grafting			$\lvert \hat{C}_i \rvert$	S the 5%
	Maturation season				
	Precocious	Average	Late		
DQI	1.420	-	1.366	0.054	0.257^{ns}
FA (cm^2)	-	305.369	298.041	7.328	46.216^{ns}
FLMM (g)	-	7.324	7.425	-0.101	1.257^{ns}
DLMM (g)	-	1.936	2.004	-0.068	0.391^{ns}
FSMM (g)	-	6.159	6.316	-0.157	0.740^{ns}
DSMM (g)	-	2.058	2.122	-0.063	0.285^{ns}
PGSFMM (g)	-	3.618	3.919	-0.301	0.419^{ns}
PGSDMM (g)	-	1.437	1.519	-0.081	0.179^{ns}
APFMM (g)	-	13.483	13.741	-0.258	1.864^{ns}
APDMM (g)	-	3.994	4.125	-0.131	0.639^{ns}
FRMM (g)	-	7.723	7.489	0.234	2.576^{ns}
DRMM (g)	-	2.001	2.195	-0.194	0.381^{ns}
TRDMM (g)	-	0.832	0.855	-0.023	0.235^{ns}
RV (cm^3)	-	7.300	7.117	0.183	2.501^{ns}
TFMM (g)	-	21.205	21.231	-0.026	3.518^{ns}
TDMM (g)	-	5.995	6.321	-0.326	0.978^{ns}
NL	-	9.988	11.216	-1.228	1.843^{ns}
PH (cm)	-	10.289	9.109	1.180	1.983^{ns}
SD (mm)	-	3.323	3.268	0.055	0.339^{ns}
HDR	-	3.108	2.793	0.315	0.654^{ns}
APRR	-	2.007	1.892	0.115	0.338^{ns}
DQI	-	1.183	1.366	-0.183	0.257^{ns}

$_{(1)}$ ^{ns} indicates non-significant and * indicates significant differences when comparisons are made ,within the grafting propagation method with the Scheffé test at a probability of 5%; the precocious, average and late maturation times were taken into account.

Although there was divergence between the genotypes with regard to height and plant architecture, color, leaf and fruit size and even in productivity, they behaved homogeneously with regard to growth as adults independent of their propagation method and degree of maturation as shown in Tables 2 and 3. For the clones of conilon coffee studied here, the adult plants have many different characteristics but the seedlings do not because they proved very homogeneous in their growth independent of the propagation system.

The cultivation of coffee, which has been commercially ongoing and exploited for many years, justifies the care taken during the production of the plantlets. Plantlets of good origins and quality are vital to the achievement of a long-lasting, productive crop and to enable the amortization of implementation costs with greater efficiency and sustainability. Therefore, the technology proposed in the present study, which consists of grafting segments of mature *C. canephora* plants onto *C. canephora* rootstocks that were propagated by seed, produces seedlings with root systems of greater mass and volume. Thus, the seedlings exhibit vigorous growth, which is certainly reflected in the number of field plants that can tolerate unfavorable abiotic conditions.

Conclusion

Based on the growth data, the method of grafting that changes the grafted cleft at the top results in perfect compatibility between the aerial parts and the rootstock.

The forting, full gap mode grafting method was found to be more effective in the production of plantlets when compared with propagation by cutting.

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