

# Grafted young coffee tree growth in a greenhouse

Marcelo Antonio Tomaz<sup>1</sup>; Ney Sussumu Sakiyama<sup>\*1</sup>; Hermínia Emília Pietro Martinez<sup>1</sup>; Antonio Alves Pereira<sup>2</sup>; Laércio Zambolim<sup>3</sup> and Cosme Damião Cruz<sup>4</sup>

<sup>1</sup>Departamento de Fitotecnia, UFV, CEP 36571-000, Viçosa, MG, Brazil; <sup>2</sup>CTZM/EPAMIG, CEP 36571-000, Viçosa, MG, Brazil; <sup>3</sup>Departamento de Fitopatologia, UFV, CEP 36571-000, Viçosa, MG, Brazil; <sup>4</sup>Departamento de Biologia Geral, UFV, CEP 36571-000, Viçosa, MG, Brazil. (\* Corresponding Author. E-mail: sakiyama@ufv.br)

## ABSTRACT

Grafted young coffee trees were observed in a greenhouse to study the effect of different scions and rootstocks on plant growth. Four *Coffea arabica* L. genotypes were used as scions: the cultivars Catuaí Vermelho IAC 15 and Oeiras MG 6851, and the progenies H 419-10-3-1-5 and H 514-5-5-3. They were also used as non-grafted control plants. Four genotypes were used as rootstocks: 'Apoatã IAC 2258' (*C. canephora*), 'Conillon' (*C. canephora*), 'Emcapa 8141' (*C. canephora*), and 'Mundo Novo IAC 376-4' (*C. arabica*). 'Mundo Novo IAC 376-4' and 'Apoatã IAC 2258' were classified as good rootstocks, while 'Oeiras MG 6851' and "H 419-10-3-1-5" performed well as non-grafted plants. The diallel analysis statistical model was efficient to evaluate the general combination ability of the rootstocks and, therefore, recommended for rootstock selection procedures in breeding programs.

**KEY WORDS:** Coffee, grafting, breeding, diallel analysis.

## INTRODUCTION

The advantages of using the grafting method have been previously reported for arabica coffee tree (*Coffea arabica* L.). For instance, in the nematode (*Meloidogyne incognita*) infested areas, the use of resistant rootstocks has increased the development and yield of grafted plants, compared to non-grafted controls (Fazuoli et al., 1983). The raw coffee productivity of Mundo Novo cultivar grafted onto a *Coffea canephora* rootstock was reported to be 4.6 times higher than the non-grafted 'Mundo Novo' control, in a nematode infested area (Costa et al., 1991). The nematode resistant rootstock cultivar Apoatã IAC 2258 (*C. canephora*) has been successfully recommended for arabica coffee commercial production in infested areas (Fazuoli et al., 2002). Positive results of arabica coffee grafted plants have been also reported when the nematode was not a concern. For instance, higher canopy and height growth rates were observed in young arabica coffee plants grafted onto *C. canephora* plants than with non-grafted control (Fahl and Carelli, 1985). Grafted plants presented significant increase of leaf area growth rates compared to the non-grafted controls, when Catimor progeny were grafted onto Caturra, Catuaí or Mundo Novo cultivars (Alves, 1986). In a experiment involving arabica coffee scions and *C. canephora* and *C. congensis* rootstocks, grafted adult arabica coffee plants were about 30%

more productive than non-grafted controls in the absence of nematode infestation (Fahl et al., 1998). In the grapevine, grafted plants show higher yield than non-grafted ones (Pauleto et al., 2001), which may be due to the better root and canopy development of the grafted plants (Edwards, 1988). Additionally, a high vigor variation among different grapevine rootstocks was observed, probably due to the differences in nutrient requirements, and water and nutrient absorption capacity (Iannini, 1984).

Grafted young coffee plants were observed in a greenhouse to study the effect of different scions and rootstocks on plant growth.

## MATERIAL AND METHODS

Sixteen different combinations of scions and rootstocks, and four non-grafted controls, were tested in this experiment. Four *Coffea arabica* L. genotypes were used as scions: the cultivars Catuaí Vermelho IAC 15 and Oeiras MG 6851, and the breeding progenies H 419-10-3-1-5 and H 514-5-5-3. They were also used as non-grafted control plants. All genotypes, but the first one, carried genes for resistance to *Hemileia vastatrix* Berk. et Br. Four genotypes were used as rootstocks: 'Apoatã IAC 2258' (*C. canephora*, resistant to *Meloidogyne incognita*), 'Conillon' (*C. canephora* collected in Muriaé, MG), 'Emcapa 8141' (*C. canephora*, also

called 'Robustão Capixaba'), and 'Mundo Novo IAC 376-4' (*C. arabica*). The grafting combinations were assigned as X/Y, where X was the scion, and Y was the rootstock.

Seeds from all genotypes were germinated in small boxes with sand, in the nursery, for 70 days. Then, the coffee scions were grafted onto the rootstock seedlings at the cotyledon stage, as described by Moraes and Franco (1973). Grafted and non-grafted seedlings were transplanted to new boxes with sand and placed in a wet chamber for 12 days. The seedlings were then transferred to the nursery. After 15 days, uniform and vigorous seedlings were transplanted to three liter cylindrical plastic pots filled with sand (one seedling per pot). The pots were, then, transferred to the greenhouse with 50% sunlight reduction screen.

The nutrient solution circulating method, a hydroponics technique described by Martinez (1999), was used. The sand used in the pots was previously treated with HCL for 24 hours, and washed several times to adjust the pH to 6. A modified Clark nutrient solution was used, containing:  $\text{N}_2\text{NO}_3$  5.7 mmol.l<sup>-1</sup>,  $\text{N}_2\text{NH}_4$  1.0 mmol.l<sup>-1</sup>, P 0.1 mmol.l<sup>-1</sup>, K 2.4 mmol.l<sup>-1</sup>, Ca 1.2 mmol.l<sup>-1</sup>, Mg 0.6 mmol.l<sup>-1</sup>, S 0.7 mmol.l<sup>-1</sup>, B 19  $\mu\text{mol.l}^{-1}$ , Cu 0.5  $\mu\text{mol.l}^{-1}$ , Fe 40  $\mu\text{mol.l}^{-1}$ ; Mn 7.0  $\mu\text{mol.l}^{-1}$ , Mo 0.09  $\mu\text{mol.l}^{-1}$ , and Zn 2.0  $\mu\text{mol.l}^{-1}$ . Two liters of this nutrient solution were added to every other pot. The nutrient solution was then collected through a ½ inch diameter tube linked to a individual collector recipient. Twice a day, the nutrient solution collected in this recipient was manually replaced in the pot, after completing the volume to two liters with deionized water. The concentration of the nutrient solution was increased 1.5, 2.5, and 3.0 fold, after 30, 60, and 90 days. The pH was maintained at  $5.5 \pm 0.5$  by daily adjustments with NaOH. The solution was replaced whenever the electric conductivity was  $60\% \pm 10\%$  from the initial one.

Data collection was performed 170 days after the experiment was set up in the greenhouse. Plant height and number of nodes were scored in the stem. Then, the plant was cut in three parts: root, stem, and leaves. Leaf area was measured with the Area meter Integrator, model 3100. Root volume and fresh weight were measured, after washing the root with water and drying on paper towels. Root total length was estimated by the line interception method (Tennant, 1975), using a sub-sample of approximately 7% of the root fresh weight. The root surface was calculated according to Bohm (1979), based on the root total length and the mean diameter.

The roots were dried at 70°C with ventilation to estimate the root dry matter weight.

The randomized complete block design was used with 20 treatments (16 grafting combinations plus four non-grafted plants) and four replications. Contrasts with the Student's *t* test at 5% of probability were used to compare pairs of means, each pair formed by the grafting combination and its respective non-grafted control. The diallel analysis model was used to assess the general combining abilities of scions and rootstocks. Data was analyzed with the statistical program GENES (Cruz, 1997).

## RESULTS AND DISCUSSION

### Comparisons of grafted plants and non-grafted controls

Plant height in the Catuaí 15/Apoatã and H 514-5-5-3/Mundo Novo combinations was significantly higher than their respective non-grafted plants in Catuaí 15 and H 514-5-5-3. The opposite was observed for the Oeiras/Apoatã, Oeiras/Conillon, Oeiras/Emcapa 8141, H 419-10-3-1-5/Conillon, H 419-10-3-1-5/Emcapa 8141, H 514-5-5-3/Conillon, and H 514-5-5-3/Emcapa 8141 combinations (Table 1). Fahl and Carelli (1985) reported that 'Mundo Novo LCM 376-4' (*C. arabica*) grafted onto the *C. canephora* genotype LCM 2258 showed higher plant height, compared to the control, which, according to them, could be due to physiological characteristics, such as better absorption or use of nutrient, and genetic characteristics.

The number of stem nodes was significantly smaller in the Catuaí 15/Conillon, Catuaí 15/Emcapa 8141, Oeiras/Emcapa 8141, and H 419-10-3-1-5/Emcapa 8141 combinations, than their respective non-grafted controls (Table 1). The lower number of stem nodes may delay the growth of lateral branches, which may cause yield reduction.

Compared to its respective non-grafted control, the progeny H 514-5-5-3 showed significant leaf area increase, when grafted onto Apoatã and Mundo Novo. The genotypes Oeiras, H 419-10-3-1-5, and H 514-5-5-3 showed decrease in leaf area, when grafted onto Conillon or Emcapa 8141. The same was observed in the genotypes Oeiras/Apoatã (Table 1). Significant increase in leaf area growth rate, compared to non-grafted controls, was previously found in "Catimor" grafted onto 'Catuaí', 'Mundo Novo', and 'Caturra' genotypes (Alves, 1986). Results showed that the greatest the leaf area, the greatest the plant capacity

to produce and store photosynthesis products (Rena and Maestri, 1985).

Root volume and root surface (Table 2) were greater for the combination H 514-5-5-3/Mundo Novo than for the H 514-5-5-3 non-grafted control. Some combinations showed no significant differences while others showed some advantages for the non-grafted control, specially when Conillon and

Emcapa 8141 were used as rootstocks. On the other hand, the genotype Oeiras had a good root system, which explains its vigorous growth under field conditions. In previous reports, Alves (1986) and Aguilar (1987) observed an increase in root volume and root surface when they used 'Catimor' grafted onto 'Catuai' and 'Mundo Novo'.

The H 514-5-5-3/Apoatã and H 514-5-5-3/Mundo

**Table 1.** Mean values for plant height (PH), number of nodes (NN), and leaf area (LA) of the non-grafted control (NG) and grafted (GR) coffee genotypes in several combinations, in nutritive solution.

Control	Grafting combination	I (cm)		NN		LA (cm <sup>2</sup> )	
		NG	GR	NG	GR	NG	GR
Catuai 15	Catuai 15/Apoatã	18.15 <sup>1/</sup>	26.96	9.25 <sup>ns</sup>	8.50	412.16 <sup>ns</sup>	470.54
Catuai 15	Catuai 15/Conillon	18.15 <sup>ns</sup>	16.13	9.25 <sup>1/</sup>	8.00	412.16 <sup>ns</sup>	293.89
Catuai 15	Catuai 15/M.Novo	18.15 <sup>ns</sup>	19.37	9.25 <sup>ns</sup>	8.75	412.16 <sup>ns</sup>	495.03
Catuai 15	Catuai 15/Emcapa 8141	18.15 <sup>ns</sup>	15.37	9.25 <sup>1/</sup>	7.75	412.16 <sup>ns</sup>	278.42
Oeiras	Oeiras/Apoatã	23.63 <sup>1/</sup>	18.00	8.75 <sup>ns</sup>	8.25	614.79 <sup>1/</sup>	338.70
Oeiras	Oeiras/Conillon	23.63 <sup>1/</sup>	15.80	8.75 <sup>ns</sup>	8.25	614.79 <sup>1/</sup>	232.71
Oeiras	Oeiras/M.Novo	23.63 <sup>ns</sup>	23.05	8.75 <sup>ns</sup>	8.00	614.79 <sup>ns</sup>	585.16
Oeiras	Oeiras/Emcapa 8141	23.63 <sup>1/</sup>	16.25	8.75 <sup>1/</sup>	7.50	614.79 <sup>1/</sup>	242.68
H 419-10-3-1-5	H 419-10-3-1-5/Apoatã	23.85 <sup>ns</sup>	21.63	9.25 <sup>ns</sup>	8.25	526.64 <sup>ns</sup>	374.94
H 419-10-3-1-5	H 419-10-3-1-5/Conillon	23.85 <sup>1/</sup>	15.15	9.25 <sup>ns</sup>	8.25	526.64 <sup>1/</sup>	196.32
H 419-10-3-1-5	H 419-10-3-1-5/M.Novo	23.85 <sup>ns</sup>	26.33	9.25 <sup>ns</sup>	8.75	526.64 <sup>ns</sup>	552.13
H 419-10-3-1-5	H 419-10-3-1-5/Emcapa 8141	23.85 <sup>1/</sup>	15.00	9.25 <sup>1/</sup>	7.75	526.64 <sup>1/</sup>	246.70
H 514 -5-5-3	H 514-5-5-3/Apoatã	22.68 <sup>ns</sup>	25.02	7.75 <sup>ns</sup>	8.50	381.29 <sup>1/</sup>	542.39
H 514 -5-5-3	H 514-5-5-3/Conillon	22.68 <sup>1/</sup>	14.30	7.75 <sup>ns</sup>	7.75	381.29 <sup>1/</sup>	161.95
H 514 -5-5-3	H 514-5-5-3/M.Novo	22.68 <sup>1/</sup>	30.88	7.75 <sup>ns</sup>	8.75	381.29 <sup>1/</sup>	634.58
H 514 -5-5-3	H 514-5-5-3/Emcapa 8141	22.68 <sup>1/</sup>	15.48	7.75 <sup>ns</sup>	7.50	381.29 <sup>ns</sup>	244.58
Df Error = 57		MSE= 12.00		MSE= 0.53		MSE= 12083.6	
		CV = 17.7		CV = 8.8		CV = 28.1	

<sup>1/</sup> significant at 5% probability, by *t* test; <sup>ns</sup> non-significant at 5% probability.

**Table 2.** Mean values for root volume (RV) and root surface (RS) of the non-grafted control (NG) and grafted (GR) coffee plants, in nutritive solution.

Control	Grafting combination	RV (cm <sup>3</sup> )		RS (cm <sup>2</sup> )	
		NG	GR	NG	GR
Catuai 15	Catuai 15/Apoatã	9.25 <sup>ns</sup>	8.50	3119.34 <sup>ns</sup>	3100.32
Catuai 15	Catuai 15/Conillon	9.25 <sup>1/</sup>	3.63	3119.34 <sup>1/</sup>	1457.85
Catuai 15	Catuai 15/M.Novo	9.25 <sup>ns</sup>	11.25	3119.34 <sup>ns</sup>	4162.55
Catuai 15	Catuai 15/Emcapa 8141	9.25 <sup>1/</sup>	5.50	3119.34 <sup>ns</sup>	2516.56
Oeiras	Oeiras/Apoatã	14.25 <sup>1/</sup>	6.75	5687.77 <sup>1/</sup>	2491.72
Oeiras	Oeiras/Conillon	14.25 <sup>1/</sup>	3.75	5687.77 <sup>1/</sup>	1346.16
Oeiras	Oeiras/M.Novo	14.25 <sup>ns</sup>	14.00	5687.77 <sup>1/</sup>	4294.00
Oeiras	Oeiras/Emcapa 8141	14.25 <sup>1/</sup>	3.25	5687.77 <sup>1/</sup>	1533.41
H 419-10-3-1-5	H 419-10-3-1-5/Apoatã	9.50 <sup>ns</sup>	8.00	3337.11 <sup>ns</sup>	3115.64
H 419-10-3-1-5	H 419-10-3-1-5/Conillon	9.50 <sup>1/</sup>	3.50	3337.11 <sup>1/</sup>	1242.93
H 419-10-3-1-5	H 419-10-3-1-5/M.Novo	9.50 <sup>ns</sup>	12.50	3337.11 <sup>ns</sup>	4085.05
H 419-10-3-1-5	H 419-10-3-1-5/Emcapa 8141	9.50 <sup>1/</sup>	3.25	3337.11 <sup>1/</sup>	1744.39
H 514-5-5-3	H 514-5-5-3/Apoatã	8.00 <sup>ns</sup>	9.00	2870.93 <sup>ns</sup>	3519.98
H 514-5-5-3	H 514-5-5-3/Conillon	8.00 <sup>1/</sup>	1.75	2870.93 <sup>1/</sup>	895.05
H 514-5-5-3	H 514-5-5-3/M.Novo	8.00 <sup>1/</sup>	12.50	2870.93 <sup>1/</sup>	4324.51
H 514-5-5-3	H 514-5-5-3/Emcapa 8141	8.00 <sup>1/</sup>	3.50	2870.93 <sup>ns</sup>	1671.22
df Error = 57		MSE= 6.82		MSE= 819398.58	
		CV = 34.4		CV = 32.0	

<sup>1/</sup> significant at 5% probability, by *t* test; <sup>ns</sup> non-significant at 5% probability.

Novo combinations showed higher root dry matter weight compared to their respective non-grafted controls. Some combinations showed no differences and others showed advantages for the non-grafted controls (Table 3).

The canopy dry matter weight was higher for combinations H 514-5-5-3/Apoatã and H 514-5-5-3/Mundo Novo, compared to their respective controls. Some combinations showed no differences and others showed advantages for the non-grafted control. (Table 3).

The increase in canopy dry matter weight, under hydroponics conditions, may be associated to a better rootstock nutritional efficiency. For instance, the Mundo Novo cultivar was reported to be more efficient than the Catuaí for absorption of N (Correia et al., 1983). In the grapevine, vigorous rootstocks showing efficient nutrient absorption produced more canopy dry matter (Albuquerque and Dechen, 2000). Under field conditions, the root system is considered a very important yield factor. A extensive root system can exploit a greater volume of soil, resulting in better water and nutrients absorption, affecting yield (Ramos and Lima, 1980; Ramos et al., 1982; Fageria, 1998).

### General combining ability of scions and rootstocks

According to the diallel analysis, there were no significant differences among scions for general

combining ability (GCA). But, differences in GCA were found among rootstocks for: plant height, number of nodes, leaf area, root volume, root surface, root dry matter weight, canopy dry matter weight, and total dry matter weight (Tables 4 and 5).

The positive value of GCA indicates the superior performance of the genotype. Apoatã and Mundo Novo rootstocks showed superior performance for all characteristics, compared to Conillon and Emcapa 8141 (Tables 4 and 5). Similarly, previous contrast analysis showed that Mundo Novo and Apoatã were, in general, superior to Conillon and Emcapa 8141, confirming that the diallel analysis was efficient to evaluate the general combining ability of rootstocks.

### CONCLUSIONS

The efficiency of the grafting technique depends not only on the rootstock, but also on the scion genotype.

Rootstocks ‘Mundo Novo IAC 376-4’ (*C. arabica*) and ‘Apoatã IAC 2258’ (*C. canephora*) had superior performance than ‘Conillon’ (*C. canephora*) and ‘Emcapa 8141’ (*C. canephora*).

The performance of the non-grafted genotypes ‘Oeiras MG 6851’ and ‘H 419-10-3-1-5’ was not improved by grafting, indicating that they may have good root systems.

**Table 3.** Mean values for dry matter weight of the root (RW), canopy (CW) and total (TW) of the non-grafted control (NG) and grafted (GR) genotypes in several combinations, in nutritive solution.

Control	Grafting combination	RW (g planta <sup>-1</sup> )		CW		TW	
		NG	GR	NG	GR	NG	GR
Catuaí 15	Catuaí 15/Apoatã	1.05 <sup>ns</sup>	1.16	3.69 <sup>ns</sup>	4.45	4.74 <sup>ns</sup>	5.61
Catuaí 15	Catuaí 15/Conillon	1.05 <sup>1/</sup>	0.54	3.69 <sup>ns</sup>	2.66	4.74 <sup>ns</sup>	3.19
Catuaí 15	Catuaí 15/M.Novo	1.05 <sup>ns</sup>	1.30	3.69 <sup>ns</sup>	4.20	4.74 <sup>ns</sup>	5.51
Catuaí 15	Catuaí 15/Emcapa 8141	1.05 <sup>ns</sup>	0.90	3.69 <sup>ns</sup>	2.38	4.74 <sup>ns</sup>	3.28
Oeiras	Oeiras/Apoatã	1.73 <sup>1/</sup>	1.02	5.59 <sup>1/</sup>	3.32	7.32 <sup>1/</sup>	4.34
Oeiras	Oeiras/Conillon	1.73 <sup>1/</sup>	0.63	5.59 <sup>1/</sup>	2.06	7.32 <sup>1/</sup>	2.68
Oeiras	Oeiras/M.Novo	1.73 <sup>ns</sup>	1.59	5.59 <sup>ns</sup>	5.29	7.32 <sup>ns</sup>	6.88
Oeiras	Oeiras/Emcapa 8141	1.73 <sup>1/</sup>	0.55	5.59 <sup>1/</sup>	2.13	7.32 <sup>1/</sup>	2.67
H 419-10-3-1-5	H 419-10-3-1-5/Apoatã	1.04 <sup>ns</sup>	1.08	4.32 <sup>ns</sup>	3.18	5.35 <sup>ns</sup>	4.27
H 419-10-3-1-5	H 419-10-3-1-5/Conillon	1.04 <sup>1/</sup>	0.48	4.32 <sup>1/</sup>	1.71	5.35 <sup>1/</sup>	2.19
H 419-10-3-1-5	H 419-10-3-1-5/M.Novo	1.04 <sup>ns</sup>	1.45	4.32 <sup>ns</sup>	5.01	5.35 <sup>ns</sup>	6.46
H 419-10-3-1-5	H 419-10-3-1-5/Emcapa 8141	1.04 <sup>1/</sup>	0.56	4.32 <sup>1/</sup>	2.04	5.35 <sup>1/</sup>	2.59
H 514 -5-5-3	H 514-5-5-3/Apoatã	0.94 <sup>1/</sup>	1.39	3.37 <sup>1/</sup>	5.04	4.23 <sup>1/</sup>	6.43
H 514 -5-5-3	H 514-5-5-3/Conillon	0.94 <sup>1/</sup>	0.37	3.37 <sup>1/</sup>	1.48	4.23 <sup>1/</sup>	1.85
H 514 -5-5-3	H 514-5-5-3/M.Novo	0.94 <sup>1/</sup>	1.43	3.37 <sup>1/</sup>	5.60	4.23 <sup>1/</sup>	7.03
H 514 -5-5-3	H 514-5-5-3/Emcapa 8141	0.94 <sup>ns</sup>	0.55	3.37 <sup>ns</sup>	2.08	4.23 <sup>1/</sup>	2.62
df Error = 57		MSE= 0.09		MSE= 0.86		MSE=1.27	
		CV = 28.7		CV = 26.4		CV = 25.2	

<sup>1/</sup>significant at 5% probability, by *t* test; <sup>ns</sup> non-significant at 5% probability.

**Table 4.** General combining ability (GCA) of grafted and non-grafted coffee tree genotypes for plant height (PH), number of nodes (NN), leaf area (LA), root volume (RV) and root surface (RS).

GCA effects of scions					
	PH <sup>ns</sup>	NN <sup>ns</sup>	LA <sup>ns</sup>	RV <sup>ns</sup>	RS <sup>ns</sup>
Catuaí 15	- 0.210	0.094	16.299	0.304	215.487
Oeiras	- 1.395	- 0.156	- 18.358	0.023	- 177.511
H 419-10-3-1-5	- 0.145	0.094	- 25.647	- 0.102	- 46.831
H 514-5-5-3	1.749	- 0.031	27.706	- 0.227	8.855
standard error (Gi):	0.719	0.160	23.222	0.646	234.371
GCA effects of rootstocks					
	PH <sup>1/1/</sup>	NN <sup>1/1/</sup>	AF <sup>1/1/</sup>	VR <sup>1/1/</sup>	SR <sup>1/1/</sup>
Apoatã	3.234	0.219	63.475	1.148	463.083
Conillon	- 4.326	- 0.094	- 146.955	- 0.758	- 1358.338
Mundo Novo	5.237	0.407	198.555	5.648	1622.691
Emcapa 8141	- 4.145	- 0.532	- 155.076	- 3.039	- 727.436
standard error (Gi):	0.719	0.160	23.222	0.646	234.371

<sup>1/1/</sup> significant at 1% probability, by the F test; ns non-significant.

**Table 5.** General combining ability (GCA) of scions and rootstocks of coffee tree genotypes for root dry matter weight (RW), canopy dry matter weight (CW) total dry matter weight (TW), and the root dry matter weight/canopy dry matter weight ratio (RW/CW).

GCA effects of scions				
	RW <sup>ns</sup>	CW <sup>ns</sup>	TW <sup>ns</sup>	RW/CW <sup>ns</sup>
Catuaí 15	0.371	0.133	0.171	0.012
Oeiras	0.010	- 0.091	- 0.081	0.009
H 419-10-3-1-5	- 0.044	- 0.302	- 0.346	0.007
H 514-5-5-3	- 0.003	0.250	0.257	- 0.028
standard error (Gi):	0.701	0.205	0.259	0.147
GCA effects of rootstocks				
	RW <sup>1/1/</sup>	CW <sup>1/1/</sup>	TW <sup>1/1/</sup>	RW/CW <sup>ns</sup>
Apoatã	0.226	0.710	0.936	0.009
Conillon	- 0.432	- 1.314	- 1.746	- 0.017
Mundo Novo	0.506	1.739	2.245	0.001
Emcapa 8141	- 0.300	- 1.134	- 1.434	0.007
standard error (Gi):	0.701	0.205	0.259	0.147

<sup>1/1/</sup> - significant at 1% probability, by the F test; ns - non-significant.

The diallel analysis statistical model was efficient in evaluating the general combining ability of the rootstocks and, therefore, recommended for rootstock selection procedures in the breeding programs.

## ACKNOWLEDGEMENTS

To CNPq, Fapemig, and the Mineral Nutrition Lab./UFV.

## RESUMO

### Crescimento de plantas jovens de café enxertado em Casa-de-vegetação

Plantas jovens de café enxertado foram avaliadas na casa-de-vegetação para se estudar o efeito de diferentes enxertos e porta-enxertos no crescimento. Quatro genótipos de *Coffea arabica* L. foram utilizados como enxertos: os cultivares Catuaí Vermelho IAC 15 e Oeiras MG 6851, e as progênies H 419-10-3-1-5 e H 514-5-5-3. Estes genótipos foram utilizados também como controles não-enxertados. Quatro genótipos foram utilizados como porta-enxertos: 'Apoatã IAC 2258' (*C. canephora*), 'Conillon' (*C. canephora*), 'Emcapa 8141' (*C. canephora*) e 'Mundo Novo IAC 376-4' (*C. arabica*). 'Mundo Novo IAC 376-4' e 'Apoatã IAC 2258' foram considerados bons porta-enxertos, enquanto que 'Oeiras MG 6851' e "H 419-10-3-1-5" tiveram bom comportamento como pés-francos. O modelo estatístico de análise dialélica foi eficiente para a avaliação da capacidade geral de combinação dos porta-enxertos, sendo, portanto, recomendado no processo de seleção dos programas de melhoramento.

## REFERENCES

Aguilar, M.A.G. 1987. Influência de diferentes porta-enxertos de *Coffea* spp., no crescimento e na seca dos ramos em progênies de Catimor (*Coffea arabica* L.). M.S. Thesis. Escola Superior de Agricultura de

Lavras, Lavras.

Albuquerque, T.C.S. and Dechen, A.R. 2000. Absorção de macronutrientes por porta-enxertos e cultivares de videira em hidroponia. *Sci. Agricola*. 57:135-139.

Alves, A.A.C. 1986. Efeito da enxertia na nutrição mineral, no crescimento vegetativo, na fotossíntese e na redução do nitrato, em *Coffea arabica* L. M.S. Thesis. Universidade Federal de Viçosa, Viçosa.

Bohm, W. 1979. Methods of studying root systems. Springer-Verlag, New York.

Clark, R.B. 1975. Characterization of phosphatase of intact morize roots. *Journal of Agric. Food Chem.* 23:458-460.

Correia, J.B.; Garcia, A.W.R. and Costa, P.C. 1983. Extração de nutrientes pelos cafeeiros Mundo Novo e Catuaí. p.117-183. In: Anais do Congresso Brasileiro de Pesquisa Cafeeira, 10<sup>th</sup>, Poços de Caldas, 1983. IBC/GERCA, Rio de Janeiro.

Costa, W.M.; Gonçalves, W. and Fazuoli, L.C. 1991. Produção de café Mundo Novo em porta-enxertos de *Coffea canephora* em áreas infestadas com *Meloidogyne incognita* raça 1. *Nematologia Brasileira*. 15:43-50.

Cruz, C. D. 1997. Programa Genes: Aplicativo computacional em Genética e Estatística. Universidade Federal de Viçosa, Viçosa.

Edwards, M. 1988. Effects of the type of rootstock on yields of Catarina grapevines (*Vitis vinifera*) and levels of citrus nematode (*Tylenchulus semipenetrans* Coob.). *Australian Journal of Experimental Agriculture*. 28(2):283-286.

Fageria, N.K. 1998. Otimização da eficiência nutricional na produção das culturas. *R. Bras. Eng. Agrícola Ambiental*. 2:6-16.

Fahl, J.I. and Carelli, M.L.C. 1985. Estudo fisiológico da interação enxerto e porta-enxerto em plantas de café. p.115-117. In: Anais do Congresso Brasileiro de Pesquisa Cafeeira, 12<sup>th</sup>, Caxambu, 1985. MIC/IBC, Rio de Janeiro.

Fahl, J.I.; Carelli, M.L.C.; Gallo, P.B.; Costa, W.M. and Novo, M.C.S.S. 1998. Enxertia de *C. arabica* sobre progênies de *C. canephora* e de *C. congensis* no crescimento, nutrição mineral e produção.

*Bragantia*. 57:297-312.

Fazuoli, L.C.; Costa, W.M. and Bortoletto, N. 1983. Efeito do porta-enxerto LC2258 de *Coffea canephora*, resistente a *Meloidogyne incognita*, no desenvolvimento e produção iniciais de dois cultivares de *Coffea arabica*. p.113-115. In: Anais do Congresso Brasileiro de Pesquisas Cafeeiras, 10<sup>th</sup>, Poços de Caldas, 1983, MIC/IBC, Rio de Janeiro.

Fazuoli, L.C.; Medina-Filho, H.P.; Gonçalves, W.; Guerreiro-Filho, O. and Silvarolla, M.B. 2002. Melhoramento do cafeeiro: variedades tipo arábica obtidas no Instituto Agrônômico de Campinas. p.163-215. In: Zambolim, L. (Ed.). O estado da arte de tecnologias na produção de café. UFV, Viçosa.

Iannini, B. 1984. Importanza e funzioni del portinnesto nella viticoltura moderna. *Riv. Vitic. Enol.* (7-8):394-419.

Martinez, H.E.P. 1999. O uso do cultivo hidropônico de plantas em pesquisa. Universidade Federal de Viçosa, Viçosa.

Moraes, M.V. and Franco, C.M. 1973. Método expedito para enxertia em café. 8p. Inst. Bras. de Café, Rio de Janeiro.

Pauleto, M.; Mourão Filho, F. A. A.; Kluge, R. A. and Scarpere Filho, J. A. 2001. Produção e vigor da videira 'Niágara Rosada' relacionados com o porta-enxerto. *Pesquisa Agropecuária Brasileira*. 36(1):115-121.

Ramos, L.C.S. and Lima, M.M.A. 1980. Avaliação da superfície relativa do sistema radicular de cafeeiros. *Bragantia*. 39:1-5.

Ramos, L.C.S.; Lima, M.M.A. and Carvalho, A. 1982. Crescimento do sistema radicular e da parte aérea em plantas jovens de cafeeiros. *Bragantia*. 41:91-99.

Rena, A.B., Maestri, M. 1985. Fisiologia do cafeeiro. *Informe Agropecuário*. 11(126):26-40.

Tennant, D. 1975. A test of a modified line intersect method of estimating root length. *J. Applied Ecol.* 63:995-1001.

Received: February 23, 2002;

Accepted: October 25, 2002.