DEVELOPMENT OF *Coffea canephora* Pierre ex A. Froehner TRANSPLANTS CULTIVATED IN DIFFERENT SUBSTRATES AND CONTAINERS

Janaína Iara Silva[1], Henrique Duarte Vieira[2], Alexandre Pio Viana[3], Deborah Guerra Barroso[2]

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ABSTRACT: In coffee transplant production, substrate is one of the factors limiting growth. The ideal substrate should meet the oxygen, water and nutrient requirements for normal plant growth. The objective of this work was to verify the effect of different substrates and containers on the growth of coffee transplants in the nursery, and also to develop a new methodology for producing *Coffea canephora* Pierre ex A. Froehner transplants using agroindustrial residues. The following containers were used: polyethylene bags, conical tubettes with 80 cc and 120 cc capacity and pressed blocks (mixture of organic material). Each treatment corresponded to one type of substrate and one type of container. The results showed that organic material may be a potential substrate for *C. canephora* transplant production. The transplants produced in the organic material, organic material + controlled nutrients, soil + cow manure + controlled nutrients substrates presented the best results for all the traits compared, in relation to the other substrates, indicating that they are the best option for producing coffee transplants. The pressed block, polyetilene bags and big size tubettes may be appropriate containers for *C. canephora* transplant production. The commercial substrate was inadequate for coffee transplant production, regardless of the container.

Key words: Nutrients, growth, production, conilon coffee.

DESENVOLVIMENTO DE MUDAS DE *Coffea canephora* Pierre ex A. Froehner EM DIFERENTES COMBINAÇÕES DE SUBSTRATO E RECIPIENTE

RESUMO: *Na produção de mudas de café, um dos fatores de restrição ao bom desenvolvimento das mudas é o substrato. O substrato ideal é aquele que satisfaz as exigências essenciais (ar, água e nutrientes) necessárias ao bom crescimento das plantas. Assim, objetivou-se neste trabalho verificar o efeito de diferentes substratos e recipientes sobre o desenvolvimento de mudas de café no viveiro, além de testar um novo método para produção de mudas de Coffea canephora Pierre ex A. Froehner, utilizando resíduos agroindustriais. Como substratos, foram utilizados uma mistura de terra e esterco de curral, Substrato comercial e o composto formado por bagaço de cana e torta de filtro, com e sem fertilizante de liberação controlada. Como recipientes, foram utilizados saquinhos plásticos, tubetes cônicos de 80 mL e 120 mL e blocos prensados. Cada tratamento foi formado pela combinação de um substrato e um recipiente diferente. Pelos resultados, verificou-se que o composto apresentou possibilidades de uso na produção de mudas de C. canephora. As mudas produzidas nos substratos composto, compostos/fertilizante de liberação controlada, terra/ esterco/fertilizante de liberação controlada, destacaram-se em todas as características, inferindo-se que essas seriam as melhores opções de substrato para produção de mudas de café. Bloco prensado, saquinho e tubete grande foram os recipientes mais indicados para a produção das mudas de C. canephora. O Substrato comercial mostrou-se inadequado para a produção de mudas de café, independentemente do recipiente.*

Palavras-chave: Nutrientes, crescimento, produção, café conilon.

1 INTRODUCTION

Brazil is the world's largest coffee producer and exporter. In the 2007/2008 harvest, production was estimated in 46 million sacks (COMPANHIA NACIONAL DE ABASTECIMENTO – CONAB), making coffee an important crop in the national agricultural scenario. The need to improve efficiency and reduce costs in the sector has prompted the search for new technologies (GUIMARÃES et al., 1998).

The type of container and its dimensions influence the quality and costs of coffee transplants (MORGADO et al., 2000), as containers whose dimensions exceed the optimum size result in

[1]Engenheira Agrônoma, Dra. em Ciência e Tecnologia de Sementes – Universidade Federal de Pelotas/UFPel – Campus Universitário, s/nº – Faculdade de Agronomia Eliseu Maciel/FAEM – Departamento de Fitotecnia – Campus Universitário – 96010-900 – Pelotas, RS – Brasil – Cx. P. – 354
[2]Engenheiros Agrônomos, Drs. em Produção Vegetal – Universidade Estadual do Norte Fluminense/UENF – Av. Alberto Lamego, 2000 – 28013-602 – Campos dos Goytacazes, RJ – Laboratório de Fitotecnia – e-mail: henrique@uenf.br, deborah@uenf.br
[3]Engenheiro Agrônomo, Dr. em Produção Vegetal – Universidade Estadual do Norte Fluminense/UENF – Av. Alberto Lamego, 2000 – 28013-602 – Campos dos Goytacazes, RJ – Laboratório de Melhoramento Genético Vegetal. e-mail: pirapora@uenf.br

unecessary expenses with materials and resources. Research has been done in various parts of the world to develop transplants with minimal root exposure in order to guarantee their protection (CARNEIRO et al., 1995).

An ideal substrate meets the physical and chemical demands and contains enough of the essential elements (air, water and nutrients) for plant growth. For Campinhos et al. (1984) and Pozza et al. (2001), the ideal environment should have a uniform composition and low density, be porous, have good field and cation exchange capacity, be free of pests, pathogenic organisms and other foreign species seeds. When manipulated in the nursery, it should be resistant to pests and diseases, operational at any moment, abundant and economically viable.

Agroindustrial residues applied in transplant production reduce costs and present environmental advantages due to the use of material which, when discarded, could cause negative environmental impacts. The construction and maintanence costs of industrial landfills and the risks the residues may represent have led to a growing interest, in many industrial sectors, in studying the viability of their application in agriculture (AMARAL et al., 1996).

Stem diameter, a non-destructive method, is easily measured and is considered by many researchers an important parameter to estimate transplant survival soon after planting in different forest species. The height of the plant aerial part, when assessed separately, is a parameter for assessing transplant quality (GOMES et al., 2002).

Among other agroindustrial residues, sugar-can bagasse and filter cake have a high potential for use in transplant production (BARROSO et al., 1998, 2000; CHAVES et al., 2003; LELES, 1998; SAMOR et al., 2002). The aim of this work was to verify the effect of different substrates and containers, with and without controlled-release fertilizer, on the development of coffee transplants in the nursery and to test a new method for producing *Coffea canephora* Pierre ex A. Froehner transplants.

2 MATERIAL AND METHODS

The experiment was set up in Campos dos Goytacazes, northern region of Rio de Janeiro state, Brazil. The transplants originated from *Coffea canephora* Pierre ex A. Froehner seeds, Robusta Tropical variety, provided by INCAPER-ES. Sowing was done directly in the substrate with two seeds per recipient. When both seeds germinated, one of the seedlings was eliminated. Cone shaped polyethylene tubettes, internally striped (8 stripes) and perforated at the extremities were used. The tubettes were 12 and 14,5 cm high and had a capacity of 80 and 120 mL, respectively, the latter considered the standard recipient for coffee transplant development (TAVARES JÚNIOR, 2004).

Perforated black plastic bags, 18 cm high x 10 cm in diameter, and pressed blocks (60 x 40 x 15 cm) made from sugar-cane bagasse and filter cake were used. When transported to the field, the blocks were separated into 40 units, individualizing each transplant.

The substrates were constituted by soil + manure (3:1, v:v), commercial coffee substrate (Plantmax café) and a sugar-cane bagasse and filter cake compound from a sugar plant (3:2, v:v), also used to manufacture the blocks. The compound (S1) contained 149 mg/dm^3 of N, 282 mg/dm^3 of P, 43 mg/dm^3 of K, 248 mg/dm^3 of Ca, 34 mg/dm^3 of Mg, 188 mg/dm^3 of S, 20,8 mg/dm^3 of Fe, 48 mg/dm^3 of copper, 11,6 mg/dm^3 of Zn, 65 mg/dm^3 of Mn and 16,2 mg/dm^3 of B. The commercial substrate (S2) was constituted by 275 mg/dm^3 of P, 620 mg/dm^3 of K, 21,1 $cmol_c/dm^3$ of Ca, 10,7 $cmol_c/dm^3$ of Mg, 354 mg/dm^3 of Fe, 0,8 mg/dm^3 of copper, 5,6 mg/dm^3 of Zn, 73,0 mg/dm^3 of Mn, 394,8 mg/dm^3 of S, 1,26 mg/dm^3 of B, while the soil + manure substrate (S3) contained 84 mg/dm^3 of P, 869 mg/dm^3 of K, 2,8 $cmol_c/dm^3$ of Ca, 2,6 $cmol_c/dm^3$ of Mg, 57 mg/dm^3 of Fe, 0,6 mg/dm^3 of copper, 2,4 mg/dm^3 of Zn, 24,8 mg/dm^3 of Mn, 154,4 mg/dm^3 of S and 0,41 mg/dm^3 of B.

To produce the compound, the sugar-cane bagasse and filter cake were mixed in a ratio of 3:2, as recommended by Morgado et al. (2000), and composted. To speed up the composting process, 6 g of N kg^{-1} mix were added. To manufacture the blocks, the compound mixture was dampened, placed in a metallic tray and pressed for 15 minutes in a manual hydraulic press at 10 Kg cm^{-2} pressure, to aggregate the material. The pressed block thus shaped was 0,15 m high x 0,40 m wide x 0,60 m long, with 0,036 m^3 volume. The trays were then removed and the blocks were placed in a box with a screen lined bottom.

A controlled-release fertilizer (flc) in a 15-10-10 + micronutrients (B 0,02 %, Cu 0,05 %, Fe 0,5 %,

Mn 0,1 %, Mo 0,004 %, Zn 0,05 %) formulation was added to half of the substrate volumes in a ratio of 36 g per 12 liters of each of the substrate mixtures, as reccommended by the manufacturer. Lower doses, such as used by Favarin et al. (2008), require complementary fertilization during the development of the coffee transplants. In the pressed blocks, the fertilizer was added before pressing.

The substrates, with and without controlled-release fertilizer, were used to fill the different containers. The sugar-cane bagasse + filter cake material was also used to manufacture the blocks, resulting in the treatments shown in Table 1.

Assessment of transplant height and stem diameter in the nursery was done every 15 days, on 12 plants per plot, during 105 days. Plant height was measured from the stem base to the apical stem using a milimeter ruler. The diameter was measured in the stem base area using a digital pachymeter.

These traits were assessed until the complete development of the transplants in the best treatments (that is, when they produced the 6th leaf pair). Three transplants were then chosen randomly from each plot and taken to the laboratory, where the leaves were removed, dehydrated, conditioned in paper bags and subjected to chemical composition analysis.

Atomic absorption spectrophotometry was used to determine Ca, Mg and micronutrient (Fe, Cu, Zn, Mn) contents. C1 was determined by titration and S by turbidimetry. B was determined by incineration in a mufla at 550ºC, colorimetry and azomethine-H. P was determined by colorimetry readings and K in the flame photometer (SILVA, 1999).

Table 1 – Coffee transplants (*Coffea canephora* Pierre ex A. Froehner) in different container and substrate combinations.

Item	Container	Substrate	Fertilization
1	Block	Compound (bagasse + filter cake 3:2)	s/flc
2	Block	Compound (bagasse + filter cake 3:2)	c/flc
3	Bag	Soil + manure (3:1)	s/flc
4	Bag	Soil + manure (3:1)	c/flc
5	Bag	Commercial substrate	s/flc
6	Bag	Commercial substrate	c/flc
7	Bag	Compound (bagasse + filter cake 3:2)	s/flc
8	Bag	Compound (bagasse + filter cake 3:2)	c/flc
9	80 mL tubette	Soil + manure (3:1)	s/flc
10	80 mL tubette	Soil + manure (3:1)	c/flc
11	80 mL tubette	Commercial substrate	s/flc
12	80 mL tubette	Commercial substrate	c/flc
13	80 mL tubette	Compound (bagasse + filter cake 3:2)	s/flc
14	80 mL tubette	Compound (bagasse + filter cake 3:2)	c/flc
15	120 mL tubette	Soil + manure (3:1)	s/flc
16	120 mL tubette	Soil + manure (3:1)	c/flc
17	120 mL tubette	Commercial substrate	s/flc
18	120 mL tubette	Commercial substrate	c/flc
19	120 mL tubette	Compound (bagasse + filter cake 3:2)	s/flc
20	120 mL tubette	Compound (bagasse + filter cake 3:2)	c/flc

flc:controlled-release fertilizer; s/: without, c/: with;

The experiment was set up in a random design with 4 replications and 12 useful plants per plot. The data were subjected to variation analysis in a factorial arrangement (treatments x assessment periods) plus additional treatment. Polinomial regression analysis was done and the Scott-Knott test was applied at 5%. Path analysis was done, as a supplement, to verify the cause/effect relations between the nutrient contents and their effects on the stem height and diameter variables.

3 RESULTS AND DISCUSSION

3.1 Height

In general, the shortest coffee transplants were those cultivated in the 80mL tubettes (Table 2). Some authors, working with tree species, have found that transplants produced in pressed blocks were longer than those produced in 50 mL tubettes (LELES et al., 2000; MORGADO et al., 2000; NOVAES, 2001).

The controlled-release fertilizer, when added to the pressed block treatment, led to longer transplants. This enhanced quality of the transplants is probably due to the greater nutrient availability in the block when the fertilizer was added (GOMES et al., 2002) (Figure 1A, Table 2).

In the transplants produced in polyethylene bags, no differences in plant height were observed between the compound + controlled-release fertilizer and soil + manure + controlled-release fertilizer substrates (Figure 1B, Table 2). The height curve of the plants produced in the commercial substrate without fertilizer was inferior to the other substrate curves, in terms of both growth rate in height and final height. These results corroborate the results found by Marana et al. (2008), who observed a lower development of arabica coffee transplants with plantmax applied without osmocote. In the polyethelyne bags, when the controlled-release fertilizer was added, the performance of the commercial and the soil + manure substrates was the same. This latter is the most widely used system for coffee transplant production in many production regions of Brazil (Figure1B, Table 2).

According to Figures 2A and 2B, the greatest plant height in the 80 mL and 120 mL tubettes was obtained with the compound and flc substrate (20,55 cm and 21,69 cm respectively), followed by the compound, soil/manure/flc and the commercial substrate with flc susbtrates, which did not differ (Table 2). The worst height results in both tubette sizes were obtained with the commercial and the soil/manure without fertilizer substrates. A similar result was found by Gualberto et al. (2000) and Marana et al. (2008) who, testing commercial substrates in 120 mL tubettes, concluded that commercial substrates provide good height growth in coffee transplants when treated with a controlled-release fertilizer (15-10-10).

The treatment height curves show that the substrates treated with 15-10-10 controlled-release fertilizer + micronutrients presented better results than the unfertilized treatments. Marana et al. (2008) and Oliveira et al. (1995) found similar results using Plantmax to produce coffee transplants in tubettes. The authors concluded that the controlled-release fertilizer enhanced plant quality and height.

3.2 Stem Diameter

Figure 3A shows a higher stem diameter growth rate in the transplants produced in blocks with the compound + controlled-release fertilizer substrate, after 30 days. This led to a significant difference in the plant diameters at the end of the nursery phase, when transplants produced with the compound substrate had a diameter of 3,38 mm, while the ones produced with the compound + fertilizer substrate reached 3,57 mm (Table 2).

Diameter growth was more accentuated in the transplants produced in bags when the soil/manure/flc substrate was used, followed by the compound/flc, soil/manure/compound substrates (Figure 3B), which presented statistically equal means (Table 2). The worst results were obtained with the commercial substrate, which presented the lowest diameter growth rate, determined by the slope of the line, and the lowest final diameter.

In the 120 mL tubettes, the highest diameter results were found for the compound/fertilizer and soil/manure/fertilizer substrates (Figure 4A, Table 2). Cunha et al. (2002), working with three tubette sizes, concluded that the best stem diameter results for *Coffea arabica* L. were obtained with the 120 mL tubettes with Plantmax treated with a controlled-release fertilizer. However, for the *C. canephora* transplants,

Table 2 – Height and stem diameter of *Coffea canephora* Pierre ex A. Froehner transplants produced in different containers and substrates after 105 days.

Treatments (substrates and containers)	Height (cm)	Treatments (substrates and containers)	Diameter (mm)
S 1 c/flc (block)	23,65 b	S 1 c/flc (120 mL tubette)	3,63 a
S 1 c/flc (bag)	26,00 a	S 3 c/flc (bag)	3,85 a
S 1 c/flc (120 mL tubette)	21,69 c	S 3 c/flc (120 mL tubette)	3,61 a
S 1 c/flc (80 mL tubette)	20,55 d	S 1 c/flc (block)	3,57 a
S 1 s/flc (block)	21,45 c	S 1 s/flc (bag)	3,60 a
S 1 s/flc (bag)	22,95 b	S 3 s/flc (bag)	3,62 a
S 1 s/flc (120 mL tubette)	18,88 d	S 2 c/flc (120 mL tubette)	3,32 b
S 1 s/flc (80 mL tubette)	16,90 e	S 1 s/flc (80 mL tubette)	3,04 b
S 2 c/flc (120 mL tubette)	17,88 e	S 1 c/flc (80 mL tubette)	3,26 b
S 2 c/flc (bag)	19,68 d	S 1 s/flc (block)	3,38 b
S 3 c/flc (bag)	25,83 a	S 1 c/flc (bag)	3,63 a
S 3 c/flc (120 mL tubette)	18,88 d	S 3 c/flc (80 mL tubette)	3,34 b
S 2 c/flc (80 mL tubette)	17,91 e	S 2 c/flc (bag)	3,27 b
S 3 s/flc (bag)	19,13 d	S 1 s/flc (120 mL tubette)	3,38 b
S 2 s/flc (bag)	8,64 g	S 3 s/flc (80 mL tubette)	2,72 c
S 2 s/flc (120 mL tubette)	8,42 g	S 2 s/flc (bag)	2,23 d
S 3 s/flc (80 mL tubette)	12,20 f	S 3 s/flc (120 mL tubette)	2,75 c
S 2 s/flc (80 mL tubette)	8,51 g	S 2 s/flc (120 mL tubette)	2,26 d
S 3 c/flc (80 mL tubette)	17,54 e	S 2 c/flc (80 mL tubette)	3,24 b
S 3 s/flc (tubete 120 mL)	7,34 g	S 2 s/flc (tubete 80 mL)	2,23 d

flc: contolled-release fertilizer. Substrates: S1 (Compound); S2 (Commercial substrates); S3 (Soil + manure);

the commercial/ controlled-release fertilizer substrate did not provide, in this container, the best conditions for good stem development and its performance was statistically inferior to the compound/fertilizer and soil/ manure/fertilizer substrates.

The most pronounced diameter growth rate in the 80 mL tubette treatment was obtained with the substrates soil/manure/controlled-release fertilizer, compound/controlled-release fertilizer, commercial substrate/controlled-release fertilizer and compound (Figure 4B) which, at the end of the cycle, did not differ (Table 2). However, for all the traits assessed, the worst results were found in the 80 mL tubettes in comparison to the other containers. This indicates that, among the containers tested, they are the least adequate for producing conilon coffee transplants.

In the 120 mL tubettes, the transplants presented greater stem diameters with the compound/controlled-release fertilizer and soil/ manure/ controlled-release fertilizer substrates (3,63 mm and 3,61 mm, respectively), in relation to the same substrates in the 80 mL tubettes (3,26 mm and 3,34 mm, respectivamente) (Table 2). This is probably due to the greater space between the transplants in the bigger tubette and also to the higher nutrient availability. Melo (1999), however, did not observe differences in the mean diameters of *C. arabica* transplants produced in these tubettes.

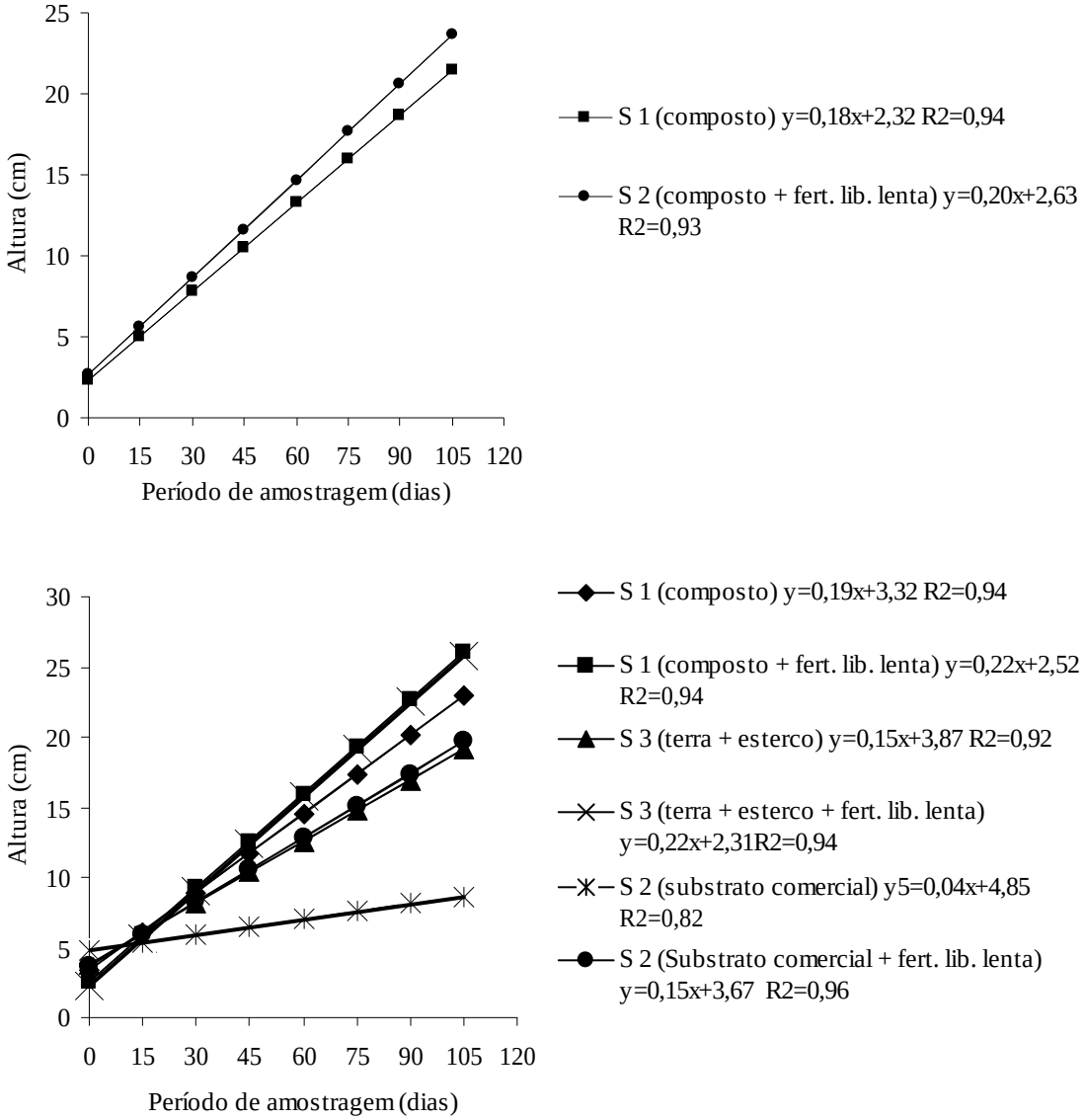

Figure 1 – Height regression equations of coffee transplants (*Coffea canephora* Pierre ex A. Froehner), in function of the periods of assessment of the different substrates in pressed block (A) and polyethelyne bags (B).

3.3 Path Analysis

The leaf Mn concentrations were adequate only in the transplants produced with the compound (bag and block) and compound/controlled-release fertilizer (small size tubette, large size tubette, block and bag) substrates. The 13 worst transplant height and diameter development rates were found in the substrates in which the transplants had Mn deficiency. Based on these results, path analysis was used to assess the effect of this micronutrient on these base-variables.

The path analysis results are shown in Table 3. Traits with high favorable correlations with the base variable, and which have a direct positive effect, are indicative of a cause/effect relation. In other words, the auxiliary trait is the main determining factor of alterations in the base variable. Mn had a direct effect, with the same signals and exceeding the residual effect estimates,

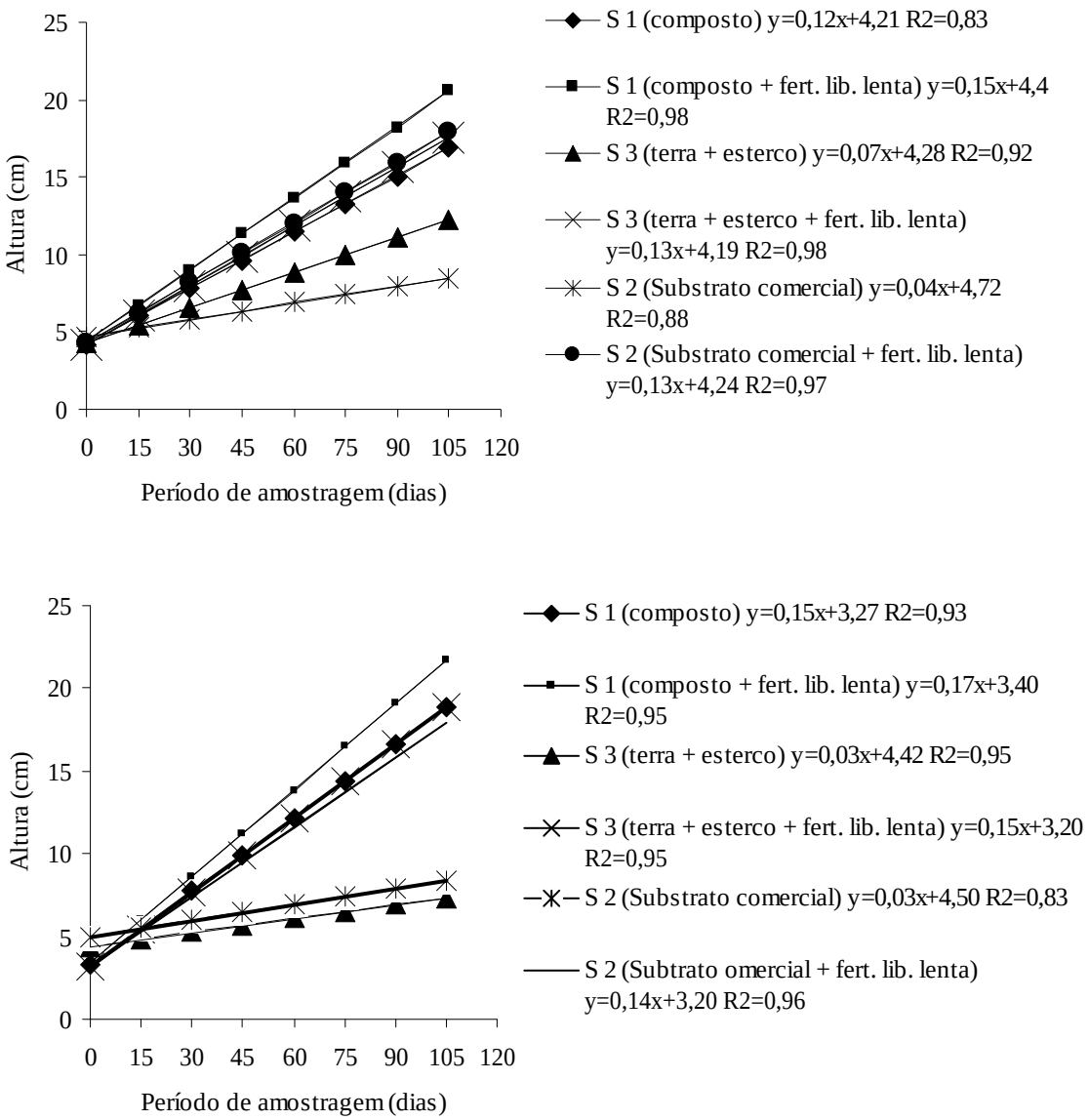

Figure 2 – Height regression equations of coffee transplants (*Coffea canephora* Pierre ex A. Froehner), in function of the periods of assessment of the different substrates in 80 mL (A) and 120 mL (B) tubettes.

on the diameter (0,9718) and height (0,8257) of the transplants produced. This shows that the auxiliary variable is the main determinant of the effects on the main variable, while the remaining nutrients have a small indirect effect. Therefore, it seems that this variable is more independent of the others, that is, it was not possible to obtain, for the remaining nutrients, consistent and significant height and diameter correlations. These results are even more significant when assessed together (0,9718 + 0,8257) since, as the two variables (height and diameter) are highly correlated, it is impractical to interpret each effect separately. This shows that the effect of Mn on the height and diameter traits is proeminent. It is important to highlight that, in studies of coffee transplant production in different substrates and containers, assessment of the plants' nutritional status is important and the nutrient above mentioned should be taken into account in fertilization management.

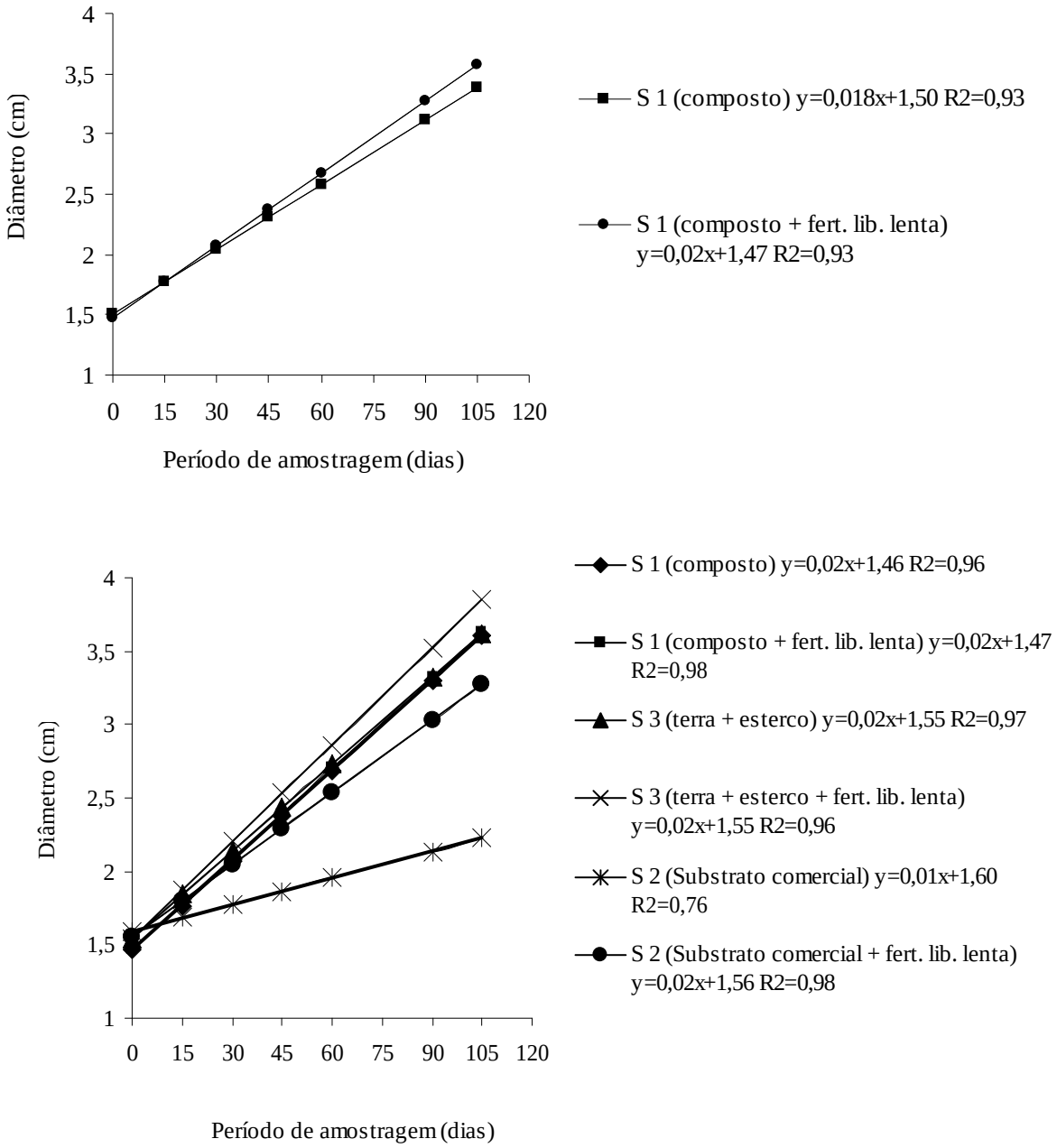

Figure 3 – Diameter regression equations of coffee transplants (*Coffea canephora* Pierre ex A. Froehner), in function of the periods of assessment of the different substrates in pressed block (A) and polyethelyne bags (B).

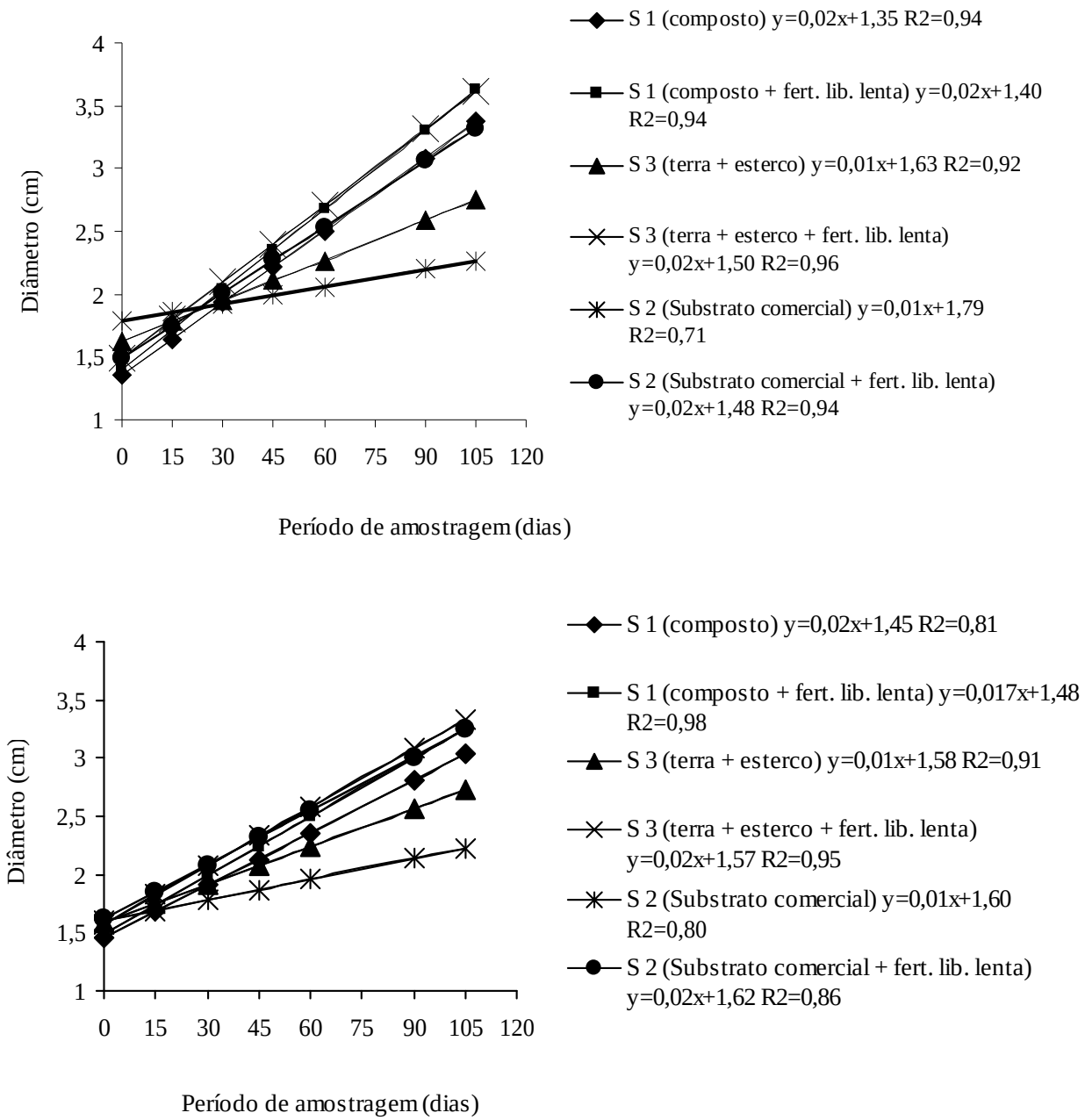

Figure 4 – Diameter regression equations of coffee transplants (*Coffea canephora* Pierre ex A. Froehner), in function of the periods of assessment of the different substrates in 120 mL (A) and 80 mL (B) tubettes.

Table 3 – Results of stem diameter and height path analysis of coffee transplants (*Coffea canephora* Pierre ex A. Froehner) produced in different containers and substrates.

Variable: Mn	Direct effect on diameter	Direct effect on height
	0,9718	0,8257
Indirect effect via N	-0,1109	-0,0278
Indirect effect via P	-0,0368	-0,2176
Indirect effect via K	0,0442	0,0096
Indirect effect via Ca	-0,2352	0,0108
Indirect effect via Mg	-0,4217	-0,3304
Indirect effect via S	0,0098	0,0069
Indirect effect via Fe	-0,0239	-0,0223
Indirect effect via Zn	-0,5067	-0,0358
Indirect effect via Cu	-0,0238	-0,0308
Indirect effect via B	0,0309	0,0404
Indirect effect via Cl	0,0535	0,0355
Total	0,2072	0,2452
Determination coefficient	0,5513	0,4236
Effect of the residual variable	0,6698	0,7591

4 CONCLUSIONS

The sugar-cane bagasse and filter cake compound was adequate for producing *C. canephora* transplants.

The compound, compound/controlled-release fertilizer and soil/manure/ controlled-release fertilizer substrates are the best options for producing *C canephora* transplants.

The commercial substrate was inadequate for production of *C.canephora* transplants, regardless of the container.

Pressed block, polyethelyne bags and large size tubette (120 mL) are the most adequate containers for producing C. *canephora* transplants.

The *C. canephora* transplants that presented the worst height and stem diameter results were Mn deficient.

5 REFERENCES

AMARAL, R. D.; BARROS, N. F.; COSTA, L. M.; FONTES, M. P. F. Efeito de um resíduo da indústria de zinco sobre a química de amostras de solo e plantas de milho. **Revista Brasileira de Ciência do Solo**, Viçosa, v. 20, n. 3, p. 433-440, 1996.

BARROSO, D. G.; CARNEIRO, J. G. A.; MARINHO, C. S.; LELES, P. S. S.; NEVES, J. C. L.; CARVALHO, A. J. C. Efeitos da adubação em mudas de sabiá (*Mimosa caesalpiniaefolia* Benth) e aroeira (*Schinus terebinthifolius* Raddi) produzidas em substrato constituído por resíduos agroindustriais. **Revista Árvore**, Viçosa, v. 1, n. 22, p. 433-441, 1998.

BARROSO, D. G.; CARNEIRO, J. G. A.; NOVAES, A. B.; LELES, P. S. S. Efeitos do recipiente sobre o desempenho pós-plantio de *Eucalyptus camaldulensis* Dehnh. e *E. urophylla* S.T. Blake. **Revista Árvore**, Viçosa, v. 1, n. 24, p. 291-296, 2000.

CAMPINHOS, J. E.; IKEMORI, Y. K.; MARTINS, F. C. G. Determinação do meio de crescimento mais adequado à formação de mudas *de Eucalyptus* sp. e *Pinnus* sp. em recipientes plásticos rígidos. In: SIMPÓSIO INTERNACIONAL: MÉTODOS DE PRODUÇÃO E CONTROLE DE QUALIDADE DE SEMENTES E MUDAS FLORESTAIS, 1984, Curitiba. **Anais**... Curitiba: UFPR, 1984. p. 350-365.

CARNEIRO, J. G. A.; BRITO, M. A. R. Nova metodologia para produção mecanizada de mudas de *Pinus taeda* L. em recipientes com raízes laterais podadas. **Revista Árvore**, Viçosa, v. 1, n. 22, p. 63-77, 1995.

CHAVES, L. L. B.; CARNEIRO, J. G. A.; BARROSO, D. G.; LELES, P. S. S. Efeitos da inoculação com rizóbio e da adubação nitrogenada na produção de mudas de sesbânia em substrato constituído de resíduos agroindustriais. **Revista Árvore**, Viçosa, v. 1, n. 27, p. 447-449, 2003.

COMPANHIA NACIONAL DE ABASTECIMENTO**. Levantamento de café 2008/2009**. Brasília, 2009. Disponível em: <http://www.conab.gov.br/conabweb/download/safra/4cafe08.pdf>. Acesso em: 18 mar. 2009.

CUNHA, R. L.; SOUZA, C. A. S.; ANDRADE NETO, A.; MELO, B.; CORRÊA, J. F. Avaliação de substratos e tamanhos de recipientes na formação de mudas de cafeeiros (*Coffea arabica* L.) em tubetes. **Ciência e Agrotecnologia**, Lavras, v. 26, n. 1, p. 7-12, 2002.

FAVARIN, J. L.; FAVARIN JUNIOR, J. L.; REIS, A. R.; CAMARGO, F. T. Metodologia para estimar a estabilidade do conjunto muda x substrato de cafeeiro. **Ciência Rural**, Santa Maria, v. 38, n. 1, 2008.

GOMES, J.M.; COUTO, L.; LEITE, H. G.; XAVIER, A.; GARCIA, S. L. R. Parâmetros morfológicos na avaliação da qualidade de mudas de *Eucalyptus grandis*. **Revista Árvore**, Viçosa, v. 26, n. 6, p. 655-664, 2002.

GUALBERTO, R.; OLIVEIRA, P. S. R.; FAVORETO, A. J. Avaliação de substratos comerciais na produção de mudas de cafeeiro (*Coffea arabica* L.) em tubetes. In: CONGRESSO BRASILEIRO DE PESQUISAS CAFEEIRAS, 26., 2000, Marília. **Resumos expandidos...** Marília: PROCAFÉ; DENAC, 2000. p. 327-328.

GUIMARÃES, P. T. G.; ANDRADE NETO, A.; BELLINI, J. O.; ADÃO, W. A.; SILVA, E. M. A produção de mudas de cafeeiros em tubetes. **Informe Agropecuário**, Belo Horizonte, n. 19, p. 98-109, 1998.

LELES, P. S. S. **Produção de mudas de *Eucalyptus camaldulensis, E. grandis* e *E. pellita* em blocos prensados e em tubetes**. 1998. 70 p. Tese (Doutorado em Produção Vegetal) - UENF, Campos dos Goytacazes, 1998.

LELES, P. S. S.; CARNEIRO, J. G. A.; BARROSO, D. G.; MORGADO, I. F. Qualidade de mudas de *Eucalyptus* spp. Produzidas em blocos prensados e em tubetes. **Revista Árvore**, Viçosa, v. 1, n. 24, p. 13-20, 2000.

MARANA, J. P.; MIGLIORANZA, E.; FONSECA, E. P.; KAINUMA, R. H. Índices de qualidade e crescimento de mudas de café produzidas em tubetes. **Ciência Rural**, Santa Maria, v. 38, n. 1, 2008.

MELO, B. **Estudos sobre produção de mudas de cafeeiros (*Coffea arabica* L.) em tubetes**. 1999. 119 p. Tese (Doutorado em Fitotecnia) - Universidade Federal de Lavras, Lavras, 1999.

MORGADO, I. F.; CARNEIRO, J. G. A.; BARROSO, D. G.; LELES, P. S. Nova metodologia de produção de mudas de *Eucalyptus grandis* ex Maiden, utilizando resíduos prensados como substrato. **Revista Árvore**, Viçosa, v. 1, n. 24, p. 27-33, 2000.

NOVAES, A. B.; CARNEIRO, J. G. A.; BARROSO, D. G.; LELES, P. S. S. Comportamento de mudas de *Pinus taeda* produzidas em raiz nua e em dois tipos de recipientes, 24 meses após o plantio. **Floresta**, Curitiba, v. 1, n. 31, p. 62-71, 2001.

OLIVEIRA, P. S. R.; GUALBERTO, R.; FAVORETO, A. J. Efeito do fertilizante de liberação controlada adicionado ao substrato comercial na produção de mudas de cafeeiro em tubetes. In: CONGRESSO BRASILEIRO DE PESQUISAS CAFEEIRAS, 21., 1995, Caxambu. **Resumos expandidos**... Caxambu: PROCAFÉ; DENAC, 1995. p. 70-72.

POZZA, A. A. A.; GUIMARÃES, P. T. G.; ROMANIELLO, M. M.; POZZA, E. A.; CARVALHO, J. G.; SILVA, E. B. Produção, nutrição e sanidade de mudas de cafeeiro em tubetes com diferentes substratos e adubações. In: SIMPÓSIO DE PESQUISA DOS CAFÉS DO BRASIL, 2., 2001, Vitória, **Resumos expandidos...** Vitória: Embrapa Café, 2001. p. 2595-2603.

SAMÔR, O. J. M.; CARNEIRO, J. G. A.; BARROSO, D. G.; LELES, P. S. S. Qualidade de mudas de angico e sesbânia, produzidas em diferentes recipientes e substratos. **Revista Árvore**, Viçosa, v. 1, n. 26, p. 209-215, 2002.

SILVA, F. C. (Org.). **Manual de análises químicas de solos, plantas e fertilizantes**. Brasília: Embrapa, 1999. 370 p.

TAVARES JÚNIOR, J. E. **Volume e granulometria do substrato na formação de mudas de café**. 2004. 59 p. Dissertação (Mestrado em Agronomia) - Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, 2004.