

Sílvia J. Ramos¹Denilson de O. Guilherme²Cecílio F. Caldeira Junior³Reginaldo A. Sampaio⁴Cândido A. da Costa⁴Luiz A. Fernandes⁴

Tomato seedling production in substrate containing coconut fiber and mushroom culture waste

ABSTRACT

The objective of this research was to evaluate the ratio of coconut fiber and mushroom culture waste in the tomato seedling production. A greenhouse experiment was carried out in the randomized block experimental design, with seven treatments and four replications: T1 - Commercial Substrate Hortimix®; T2 - 0% coconut fiber dry matter (CF) + 100% dry matter of mushroom culture waste (MW); T3 - 20% (CF) + 80% (MW); T4 - 40% (CF) + 60% (MW); T5 - 60% (CF) + 40% (MW); T6 - 80% (CF) + 20% (MW); T7 - 100% (CF) + 0% (MW). Stem diameter, seedling height, emergence speed, germination percentage, shoot and root fresh matter and shoot and root dry matter were evaluated. It was evidenced, for all the studied characteristics, with exception of the speed of germination-aid seedling emergence and of the germination percentage, significant differences between substrate containing coconut fiber and mushroom culture residue and the commercial substratum, the best results presented by the last one. The increase in the proportion of mushroom residue in relation to the coconut fiber provided tomato seedling with better characteristics than the others.

Key words: organic substrate, recycling, organic manure, germination

Produção de mudas de tomate em substrato contendo fibra de coco e resíduo de cultivo de cogumelo

RESUMO

Visou-se, com o presente trabalho, avaliar proporções de fibra de coco e de resíduo proveniente do cultivo de cogumelo como substratos para a produção de mudas de tomate. O experimento foi conduzido em casa de vegetação, tendo-se utilizado o delineamento em blocos inteiramente casualizados, com sete tratamentos e quatro repetições: T₁ - Substrato comercial Hortimix®; T₂ - 0% matéria seca de fibra de coco (FC) + 100% matéria seca de resíduo proveniente do cultivo de cogumelo (RC); T₃ - 20% FC + 80% RC; T₄ - 40% FC + 60% RC; T₅ - 60% + 40% RC; T₆ - 80% FC + 20% RC; T₇ - 100% FC + 0% RC. Avaliaram-se o diâmetro do caule, a altura da planta, o índice de velocidade de emergência, a percentagem de germinação, a matéria fresca da parte aérea e da raiz, e a matéria seca da parte aérea e da raiz. Constataram-se, para todas as características estudadas, com exceção do índice de velocidade emergência e da percentagem de germinação, diferenças significativas entre os substratos contendo fibra de coco e resíduo do cultivo de cogumelo e o substrato comercial, em que este último apresentou os melhores resultados. O aumento da proporção de resíduo de cogumelo em relação à fibra de coco proporcionou a produção de mudas com melhores características que as demais.

Palavras-chave: substrato orgânico, reciclagem, adubo orgânico, germinação

¹ Doutorando em Ciência do Solo, DCS-UFLA. Bolsista do CNPq, silviojramos@gmail.com

² Mestre em Agroecologia, doliveiraguilherme@yahoo.com.br

³ Mestrando em Fisiologia Vegetal, DBI-UFLA agrosuacui@yahoo.com.br

⁴ Prof. Adjunto, ICA-UFMG, rsampaio@ufmg.br, candido-costa@ufmg.br, larnaldo@ufmg.br

INTRODUCTION

The base of the modern agriculture is the production of high quality seedlings, which in general, is part of the strategy to improve agriculture, and in a certain way to reduce the environmental impact caused in the soil. In this way, Andriolo et al. (1999) relate that substrate cultivation demonstrate great progress in relation to soil cultivation systems, because they offer advantages such as more appropriate water management, the supply of nutrients in doses and at appropriate times, reduced salinization risk of the root environment and the reduction of the occurrence of plant health problems, that are translated as direct benefits to the income and to the quality of the picked products. As consequence, as reported by Minami (1995), the chances of success of the crop are 60%. In spite of the higher cost and demanding a better technological level, if compared to the use of the soil, this cultivation technique in substrate has been attracting producers in several countries (Riviere & Caron, 2001)

The term substrate applies to all solid material, natural, synthetic, residual, mineral or organic, distinct from the soil, which when placed in a receptical in pure or mixed form permits the development of a root system, carrying out, therefore, a support role for the plant. As desirable characteristics, the substrates should present low cost, availability near the consumption areas, sufficient nutrient level, good cation exchange capacity, relative biological sterility, allow aeration and humidity retention, being of easy use, long durability and recyclable (Konduru et al., 1999; Booman, 2000), besides favoring physiological root activity (Gonçalves et al., 2000).

Alternative substrates of vegetable origin have been recommended for the production of seedlings and the cultivation of plants (Souza, 2001). In general, it is observed that different types of agroindustrial residues are progressively being applied as substrate (rice husk, cane pulp, pine nut seeds, paper production residue), (Chong, 1999; Souza, 2001; Sainju et al., 2001), seeking to offer alternatives for producing seedlings and to minimize the environmental impact produced by the generated solid residues.

An alternative to the high cost of the commercial substrates is the use of regional raw materials such as the fiber of green or ripe coconut that is easy to obtain. According to Carrijo et al. (2002), the good physical properties of the coconut fiber, its non-reaction with the nutrients from fertilization, its long durability without alteration of physical characteristics, the sterilization possibility, the abundance of the raw material that is renewable and the low cost for the producer makes green coconut fiber a substrate difficult to replace with other material types, mineral or organic, in vegetables cultivation without soil. In this context, Silveira et al. (2002) observed in tomato cv. Santa Adélia, that the coconut powder, although providing a larger germination percentage (90.63%) than the commercial substrate (67.18%), produced seedlings which were less vigorous than in the commercial substrate, the problem being corrected when the coconut powder was mixed with the earthworm humus.

Carrijo et al. (2001), Pragana (1998) and Andriolo et al. (1997) highlighted the possibility of the use of partially charred rice

husk and of green coconut fiber as substrate for the cultivation of the tomato plant. Silveira et al. (2002) verified that the use of green coconut powder as substrate reduced the cost of the production of tomato plant seedlings by about 47%. Bezerra & Rosa (2002) verified that the use of the green coconut powder as substrate for chrysanthemum stem cuttings rooting has made the formation of roots with larger volume and thickness and high rooting percentage possible.

Among the several materials with potential for substrate production besides the coconut husk, the residue from the production of the sun mushroom (*Agaricus blazei*), can be mentioned, which besides the economical aspect, also stands out in this case because of the environmental importance of the agricultural use of this residue which has been currently under production on a wide scale.

In view of this, the main objective of this work is to study the use of the coconut fiber associated to the residue used in the cultivation of the sun mushroom (*Agaricus blazei*), substrate for the production of tomato seedlings cultivation.

MATERIAL AND METHODS

The experiment was done in the greenhouse at the Institute of Agrarian Science of Federal University of Minas Gerais, using as indicator plant the tomato (*Lycopersicon esculentum* Mill, cv. Kada Gigante).

The treatments were composed of seven substrate types: T₁ - commercial substrate Hortimix®; T₂ - 0% coconut fiber dry matter (CF) + 100% dry matter of mushroom (*Agaricus blazei*) culture waste (MW); T₃ - 20% (CF) + 80% (MW); T₄ - 40% (CF) + 60% (MW); T₅ - 60% (CF) + 40% (MW); T₆ - 80% (CF) + 20% (MW); T₇ - 100% (CF) + 0% (MW). The chemical characteristics of the materials used as substrates are found in Table 1.

Sowing was done in expanded polystyrene trays, containing 128 cells, a seed being put in the center of each tray

Table 1. Chemical and physical characteristics of the different materials used in preparation of the substrate for the production of tomato seedlings

Tabela 1. Características químicas e físicas dos diferentes materiais utilizados na preparação dos substratos utilizados para o cultivo de mudas de tomate

Characteristics	Comercial Substrate	Mushroom Residue	Coconut Fiber
pH H ₂ O (1:2.5)	6.75	6.48	6.62
N total ² (dag kg ⁻¹)	1.83	0.73	0.56
P available ³ (dag kg ⁻¹)	0.92	0.15	0.15
K ³ (dag kg ⁻¹)	0.39	0.34	1.15
Ca ⁴ (dag kg ⁻¹)	0.24	3.82	0.45
Mg ⁴ (dag kg ⁻¹)	0.89	0.89	0.20
S (dag kg ⁻¹)	0.03	0.18	0.02
Zn ⁵ (dag kg ⁻¹)	16.1	37.6	12
Cu ⁵ (dag kg ⁻¹)	14.5	14.9	0.3
Mn (dag kg ⁻¹)	45.1	157.7	14
Water retention capacity (g H ₂ O g ⁻¹ substrate)	2.7	2.59	3.0
C.E. ⁶ (mS cm ⁻¹)	1.8	2.34	2.18

¹ Irrigation loss method (Kiehl, 1985); ² Kjeldahl Micro-method (Kiehl, 1985); ³ Extratos Mehlich-1 (Defelipo & Ribeiro, 1981); ⁴ Extrator KCl 1 mol L⁻¹ (Defelipo & Ribeiro, 1981); ⁵ Extrator HNO₃/HClO₄; ⁶ Saturation extract in ratio 1:5 (Tedesco et al., 1995)

cell. The experiment was conducted in randomized block design, with four repetitions. The experimental unit was made up of 16 plants, the diameter of the base of the hypocotyl (D), the height of the plant (H), emergence speed index (ESI), germination percentage (G), shoot (SFM) and root (RFM) fresh matter, plus the shoot (SDM) and root (RDM) dry matter were appraised.

Germination was evaluated at 20 days after sowing, germinated seeds being considered those that emitted the caulicle. The height of the plant, measured from the base of the hypocotyl to the seedling's apex, and the diameter of the hypocotyl in the area of the base, were appraised at 28 days after sowing. The obtained data were submitted to variance analysis and the averages of the proportions of coconut fiber and mushroom residue were compared with those of the commercial substrate until 5% of probability by the Dunnett's test. The averages regarding the proportions of coconut fiber and residue were adjusted to regression models until 5% of probability for the t test.

RESULTS AND DISCUSSION

Significant differences among the substrates of coconut fiber and mushroom cultivation residue and the commercial substrate (Hortimix®) were observed for all the studied variables (Table 2) except the speed emergence index (SEI) and the germination percentage, the commercial substrate present the best results. Pragma (1998) and Silveira et al. (2002), verified that the use of the substrate containing coconut fiber provided germination of the tomato plant similar to the commercial substrate, possibly in reason of the high water retention capacity of this residue. Correia et al. (2003) and Bezerra et al. (2004) verified that the use of the coconut fiber can constitute an important component in the substrate mixture for the production of seedlings. Besides, it provide an appropriate alternative use for the coconut residues agribusiness.

The maximum germination percentage (90.23%), was observed with 52.97% of coconut fiber in relation to the mushroom cultivation residue (Figure 1A). Very high amounts of mushroom cultivation residue or of coconut fiber in the substrate composition provided a low germination percentage.

Such fact can be related to the reduction of the aeration of the substrate due to the total completion of the macropores of the coconut fiber with the mushroom cultivation residue or of the low humidity of the substrate in contact with the seed. Minami (1995) mentions that the substrate is the most sensitive and complex component of the seedling production system, because any variation in its composition can alter the final process of seedling production, from germination of seeds to the irregular development of the plants.

The emergence index speed (ESI) decreased with the increase in the proportion of coconut fiber in the substrate, especially for the pure mushroom cultivation residue (0% coconut fiber + 100% mushroom residue) which provided the highest index (Figure 1B).

The diameter of the hypocotyl presented a trend towards minimum diameter of 0.77 mm when 74.51% coconut fiber was used in the mixture with mushroom cultivation residue. On the other hand, values below 74.51% of the proportion of coconut fiber in the constitution of the substrate promoted an increase in the diameter, having a better development when the mushroom cultivation residue was used pure (Figure 1C). This superiority of the mushroom residue in the development of the seedlings can be explained by the higher availability of nutrients, as presented in Table 1.

The response of seedling height of the tomato plant in relation to the mixture of the coconut fiber with mushroom cultivation residue was quadratic (Figure 1D), a maximum height of 1.94 cm, being obtained with the relationship of 66.36%, this variable has presented larger values with the increase in the proportion in the mushroom residue substrate. As already discussed, one can attribute such fact to the higher availability of nutrients verified in the mushroom residue.

In relation to the fresh and dry matter of the shoot, it was verified that the smallest values obtained for these variables were, respectively, 0.02 and 0.002 g, in the proportion of coconut fiber and mushroom cultivation residue of 63.68 and 61.21% (Figure 2A and B).

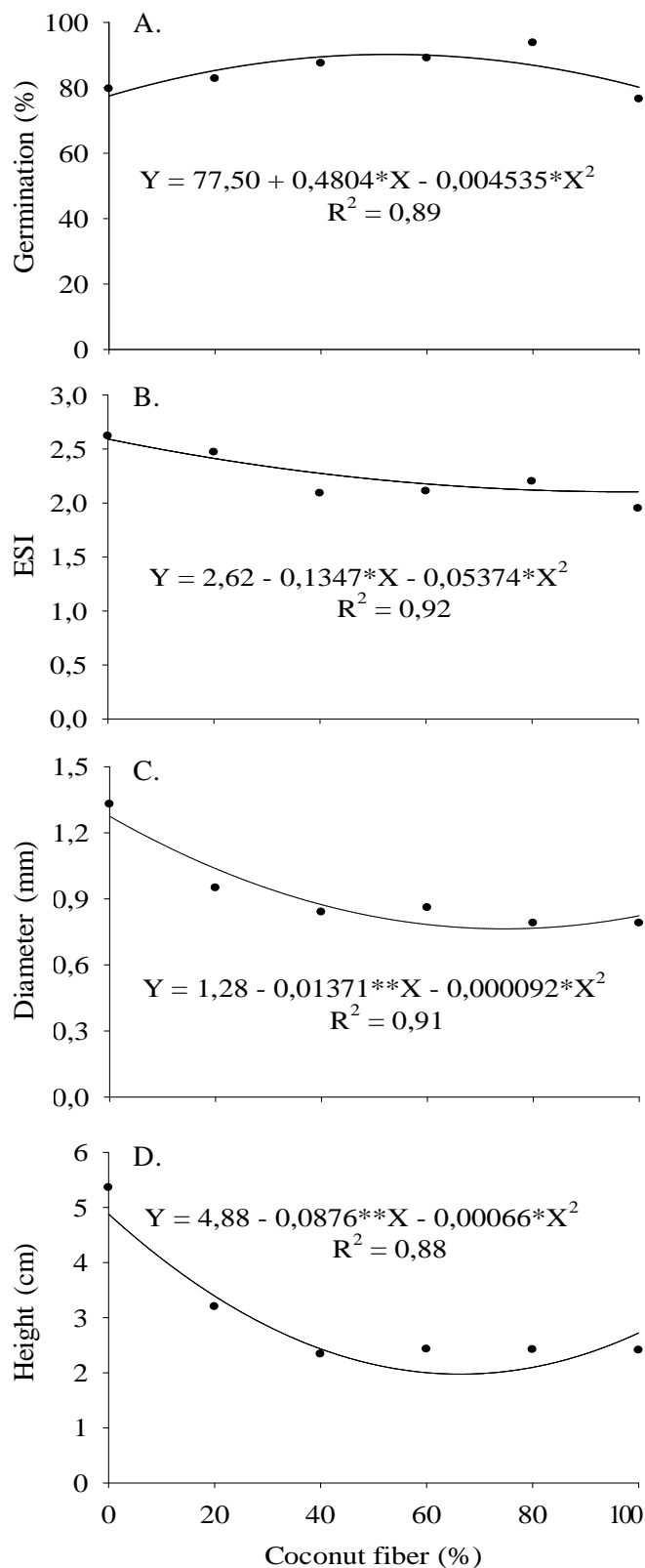
The fresh and dry matter of the root presented larger values when the mixture of coconut fiber and mushroom cultivation residue was prepared with a higher percentage of latter. The smallest values observed for the root matter were

Table 2. Mean values of diameter (D), height (H), emergence speed index (ESI), germination (G), shoot fresh matter (SFM), root fresh matter (RFM), shoot dry matter (SDM), root dry matter (RDM) of tomato in deferent substrates

Tabela 2. Valores médios obtidos de diâmetro, altura, índice de velocidade de emergência (IVE), germinação (G), massa fresca parte aérea (MFPA), massa fresca sistema radicular (MFSR), massa seca parte aérea (MSPA), massa seca sistema radicular (MSSR) de tomate em diferentes substratos

SUBSTRATES	D (mm)	H (cm)	ESI	G %	SFM (g)	RFM (g)	SDM (g)	RDM (g)
0% CF+ 100% MR	1.3*	5.36*	2.62 ^{ns}	79.68 ^{ns}	0.3251*	0.1844*	0.0327*	0.0096*
20% CF + 80% MR	0.95*	2.57*	2.47 ^{ns}	82.81 ^{ns}	0.0449*	0.0258*	0.0053*	0.0021*
40% CF + 60% MR	0.84*	2.34*	2.09 ^{ns}	87.50 ^{ns}	0.0315*	0.0317*	0.0034*	0.0017*
60% CF + 40% MR	0.86*	2.43*	2.11 ^{ns}	89.06 ^{ns}	0.0346*	0.0268*	0.0041*	0.0057*
80% CF + 20% MR	0.79*	2.42*	2.44 ^{ns}	93.75 ^{ns}	0.0387*	0.0224*	0.0050*	0.0021*
100% CF + 0% MR	0.79*	2.41*	1.95 ^{ns}	76.56 ^{ns}	0.0413*	0.0247*	0.0047*	0.0020*
Comercial Substrate	2.33	8.07	2.58	84.37	0.7886	0.5831	0.0737	0.0236
(ASD)	0.47	0.89	0.69	16.75	0.127	0.1281	0.0330	0.0121

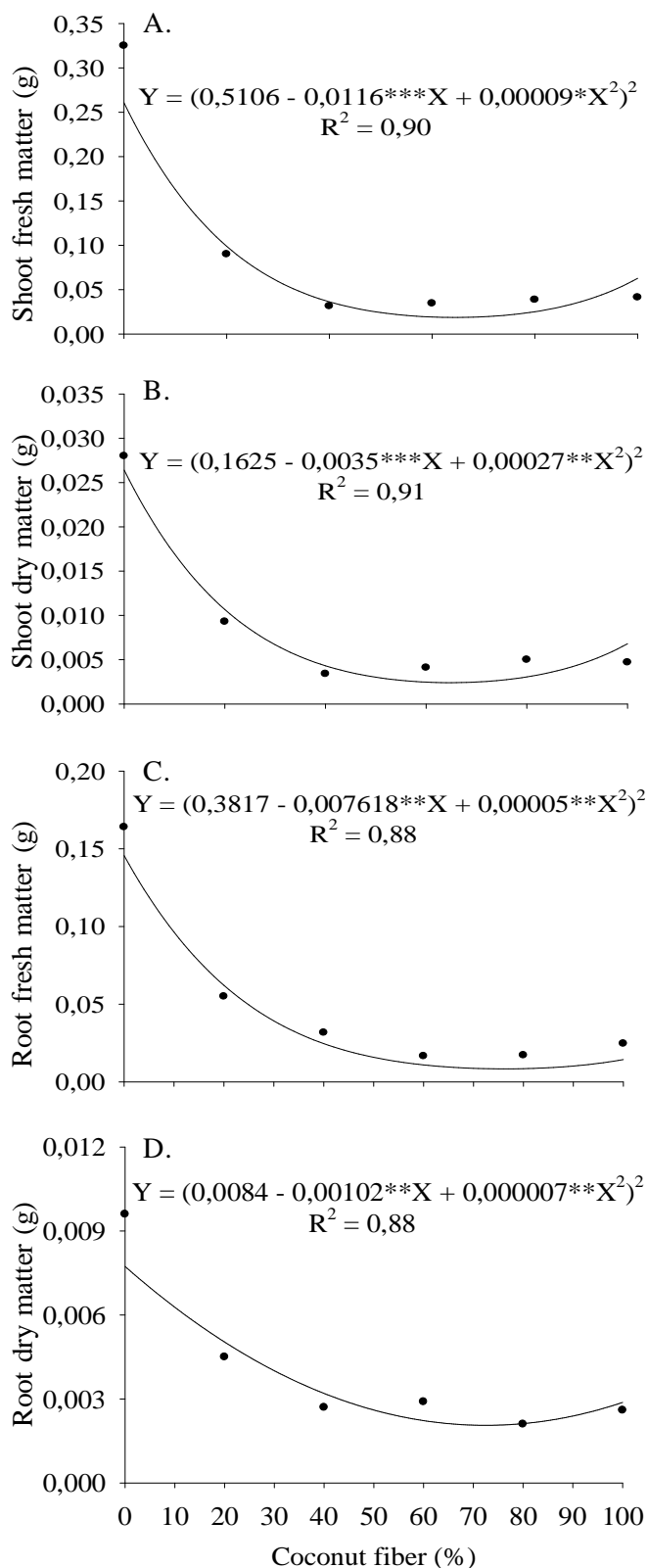
CF = Coconut fiber; MR = Mushroom cultivation residue (*Agaricus blazei*). ^{ns} No statistical difference; * Differ statistically by the Dunnett test at 5% of probability in comparation with the comercial substrate



*, **, *** Significant at 5, 1 e 0.1% of probability, respectively, by t test

Figure 1. Germination (A), emergence speed index (ESI) (B), diameter (C), height (D) of tomato seedlings as a function of percentage of coconut fiber.

Figura 1. Germinação (A), índice de velocidade de emergência (B), diâmetro (C), altura (D) de plântulas do tomateiro em função da porcentagem de fibra de coco



*, **, *** Significant at 5, 1 e 0.1% of probability, respectively, by t test

Figure 2. Shoot fresh matter (A), shoot dry matter (B), root fresh matter (C) and root dry matter (D) of tomato plant seedlings as a function of percentage of coconut fiber

Figura 2. Matéria fresca da parte aérea (A), matéria seca da parte aérea (B), matéria fresca da raiz (C), matéria seca da raiz (D) de plântulas do tomateiro em função da porcentagem de fibra de coco

0.0083 and 0.00081g, obtained with coconut fiber proportions of 77.04 and 65.92%, respectively (Figure 2C and 2D).

The superiority of the mushroom residue in relation to the development of the seedlings for most of the variables studied can be explained by the higher availability of nutrients in the mushroom residue, as shown in Table 1. According to Rosa et al. (2001), one of the main limitations of the use of coconut fiber as substrate is the low availability of nutrients. However, Kämpf & Fermino (2000), point out that the negative effect of the coconut fiber in the substrate on the plant characteristics can be related to the possible presence of soluble tannins that, when very concentrated in the coconut fiber, are phytotoxic and inhibit root growth, affecting the growth of the plants.

CONCLUSION

Increasing the proportion of coconut fiber to mushroom culture waste resulted in an increase of percentage of emergence, however, the index of emergence, stem diameter, seedling height, shoot and root fresh and dry mass decreased.

Considering the highly favorable conditions of the mushroom residue in relation to the coconut fiber, a higher proportion of the mushroom cultivation residue is recommended in the substrate composition for the production of tomato seedlings.

LITERATURE CITED

- Andriolo, J. L.; Duarte, T. S.; Ludke, L.; Skrebsky, E. C. Crescimento e desenvolvimento do tomateiro cultivado com substrato com fertirrigação. *Horticultura Brasileira*, v.15, n.1, p.28-32, 1997.
- Andriolo, J. L.; Duarte, T. S.; Ludke, L.; Skrebsky, E. C. Caracterização e avaliação de substratos para o cultivo do tomate fora do solo. *Horticultura Brasileira*, v.17, n.3, p.215-219, 1999.
- Bezerra, A. M. E.; Momenté, V. G.; Araújo, E. C.; Medeiros Filho, S. Germinação de sementes e desenvolvimento de plântulas de moringa (*Moringa olifera* Lam.) em função do peso da semente e do tipo de substrato. *Horticultura Brasileira*, v.22, n.2, p.295-299, 2004.
- Bezerra, F. C.; Rosa, M. F. Caracterização, manejo e qualidade de substratos para produção de plantas: pó da casca de coco verde como substrato para plantas. In: Encontro nacional de substratos para plantas, 3., 2002, Campinas. *Anais...* Campinas: IAC, 2002. p.94.
- Booman, J. L. E. Evolução dos substratos usados em horticultura ornamental na Califórnia. In: Kämpf, A. N.; Fermino, M.H. (ed.). *Substratos para plantas: a base da produção vegetal em recipientes*. Porto Alegre: Gênese, 2000. p.43-65.
- Carrijo, O. A.; Liz, R. S.; Makishima, N. Fibra da casca do coco verde como substrato agrícola. *Horticultura Brasileira*, v.20, n.4, p.533-535, 2002.
- Carrijo, O. A.; Reis, N. V. B.; Makishima, N.; Moita, A. W. Avaliação de substratos e modelos de casa de vegetação para o cultivo de tomate na região de Brasília. *Horticultura Brasileira*, v.19. Suplemento. 2001, CD-Rom.
- Chong, C. Experiences with the utilization of wastes in nursery potting mixes and field soil amendments. *Canadian Journal of Plant Science*, v.79, n.1, p.139-148, 1999.
- Correia, D.; Rosa, M.F.; Norões, E.R.V.; Araujo, F.B. de. Uso do pó de coco na formulação de substratos para formação de mudas enxertadas de caju anão precoce. *Revista Brasileira de Fruticultura*, v.25, n.3, p.557-558, 2003.
- Defelipo, B. V.; Ribeiro, A. C. Análise química do solo. Viçosa: Universidade Federal de Viçosa, 1981. 17p. (Boletim Extensão, 29).
- Gonçalves, J. L. M.; Santareli, E. G.; Moraes Neto, S. P.; Manara, M. P. Produção de mudas de espécies nativas: substrato, nutrição, sombreamento e fertilização. In: Gonçalves, J. L. M.; Benedetti, V. (ed.). *Nutrição e fertilização florestal*. Piracicaba: IPEF, 2000. p.309-350.
- Kämpf, A. N.; Fermino, M. H. Seleção de materiais para uso como substrato. In: *Substratos para plantas: a base da produção vegetal em recipientes*. Porto Alegre: Gênese. 2000, p. 139-145.
- Kiehl, J. E. Fertilizantes orgânicos. Piracicaba: Agrônômica Ceres, 1985. 492p.
- Konduru, S.; Evans, M. R.; Stamps, R. H. Coconutnut husk and processing effects on chemical and physical properties of coconutnut coir dust. *HortScience*, v.34, p.88-90, 1999.
- Minami, K. Fisiologia da produção de mudas. São Paulo: T. A. Queiroz, 1995. 129p.
- Pragana, R. B. Potencial do resíduo da extração da fibra de coco como substrato na produção agrícola. Recife: Universidade Federal Rural de Pernambuco, 1998, 84p. Dissertação de Mestrado.
- Riviere, L. M.; Caron, J. Research on substrates: state of the art and need for the coming 10 years. *Acta Horticulturae*, n.548, p. 29-41. 2001.
- Rosa, M. F.; Santos, F. J. S.; Montenegro, A. A. T.; Abreu, F. A. P.; Correia, D.; Araújo, F. B. S. Caracterização do pó da casca de coco verde usado como substrato agrícola. Fortaleza: Embrapa-CNPAT, 2001. 6p. (Comunicado Técnico, 54).
- Sainju, U. M.; Rahman, S.; Singh, B. P. Evaluating hairy vetch residue as nitrogen fertilizer for tomato in soilless medium. *HortScience*, v.36, n.1, p.90-93, 2001.
- Silveira, E. B.; Rodrigues, V. J. L. B.; Gomes, A. M. A.; Mariano, R. L. R.; Mesquita, J. C. P. Pó de coco como substrato para produção de mudas de tomate. *Horticultura Brasileira*, v.20, n.2, p.211-216, 2002.
- Souza, F. X. Materiais para formulação de substratos na produção de mudas e no cultivo de plantas envasadas. Fortaleza: Embrapa-CNPAT, 2001. 21 p. (Documentos, 43).
- Tedesco, M. J.; Gianello, C.; Bissani, C. A.; Bohnen, H.; Volkweiss, S. J. Análises de solo, plantas e outros materiais. Porto Alegre: Universidade Federal do Rio Grande do Sul, 1995. 174p. (Boletim Técnico, 5).