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SEEDLING GROWTH OF *Allophylus edulis* IN DIFFERENT SUBSTRATES

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ABSTRACT

Seedling production of native species is a critical factor involved in forest restoration. Considering this, our study aimed to evaluate the development of seedlings of *Allophylus edulis* on different substrates compositions. The experiment was implemented in a randomized block design with four treatments, six replications, and eight seedlings in each block. The substrates were prepared using different proportions and combinations of pine bark and vermiculite (PBV), carbonized rice husk (CRH), mixed coconut fiber (MCF), granulated coconut fiber (GCF), and vermicompost (VC) in four treatments: T1 = 100% PBV; T2 = 70% PBV + 20% CRH + 10% VC; T3 = 70% PBV + 20% GCF + 10% VC; T4 = 70% PBV + 20% MCF + 10% VC. Seedling growth was quantified based on height, stem base diameter, leaf area and dry biomass (aerial parts, roots and whole plant). Data analysis was performed using analysis of variance and tests of means. Our results demonstrated that the substrate effect was significant after 135 days for height, stem base diameter and leaf area ($p > 0.01$) but not for dry biomass ($p < 0.01$). Treatments T2 and T3 produced the best results for the assessed variables. They had different compositions; one had carbonized rice husk, and the other had mixed coconut fiber. Recommended choice between them should be based on availability and local production costs.

KEYWORDS: Seedling production; Morphology; Forest species.

CRESCIMENTO DE MUDAS DE *Allophylus edulis* PRODUZIDAS EM DIFERENTES SUBSTRATOS

RESUMO

Produzir mudas de espécies florestais nativas com qualidade é um dos fatores mais importantes na restauração de ambientes naturais degradados. Levando isto em consideração, este estudo objetivou avaliar o desenvolvimento de mudas de *Allophylus edulis* cultivados em substratos com diferentes composições. O experimento foi conduzido em blocos casualizados, com quatro tratamentos e seis repetições, sendo oito mudas por bloco. Os substratos foram preparados utilizando diferentes proporções e combinações dos materiais: casca de pinus e vermiculita (PBV), casca de arroz carbonizada (CRH), fibra de coco mista (MCF), fibra de coco

granulada (GCF) e vermicomposto (VC); em quatro tratamentos: T1 = 100% PBV; T2 = 70% PBV + 20% CRH + 10% VC; T3 = 70% PBV + 20% GCF + 10% VC; T4 = 70% PBV + 20% MCF + 10% VC. O crescimento das mudas foi quantificado em função da altura, diâmetro do colo, área foliar e biomassa seca (parte aérea, raízes e total). Os dados foram avaliados a partir de análises de variância e testes de médias. Os resultados encontrados demonstraram que os efeitos das diferentes combinações dos substratos foram significativos para altura da muda, diâmetro do colo e área foliar ($p < 0,01$); não apresentando diferenças estatísticas significativas para biomassa seca ($p > 0,01$). Os tratamentos T2 e T3, que proporcionaram os melhores resultados, diferem na presença da casca de arroz carbonizada ou da fibra de coco mista. Recomenda-se que a escolha entre eles seja feita baseada na disponibilidade e nos custos de produção local.
PALAVRAS-CHAVE: *Produção de mudas; Morfologia; Espécies florestais.*

INTRODUCTION

Deforestation in southern Brazil has increased in the last century, producing irreversible changes in plant physiognomies underwent rapid industrialization and urbanization (LACERDA *et al.*, 2020). As a result of human actions, degraded areas and fragmented landscapes occupy large portions of the territory, increasing the risk of extinction of endemic species and reducing overall biodiversity (SEMPER-PASCUAL *et al.*, 2021).

Seedling production of native species is a critical factor involved in forest restoration. There is an increasing need for research methods that improve the seedling production at low cost and with morphophysiological quality to obtain forest materials that may become more competitive enough to overcome invasive species and weed competition (FARIA *et al.*, 2019; LIMA FILHO *et al.*, 2019). Choosing the most suitable substrate for each plant species is of fundamental importance to produce quality seedlings with good field survival rate and low cost. However, it is difficult to find substrate materials that contain all desirable characteristics by themselves. Normally, this could be accomplished by finding suitable materials and using the best mixture ratio to enhance the properties of the final product (CHANG *et al.*, 2021).

The species under study, *Allophylus edulis* (A. St.-Hil., A. Juss. & Cambess.) Hieron. ex Niederl., is a member of Sapindaceae family and known locally as “vacum” and “chal-chal”. *A. edulis* is considered a pioneer and ornamental species, producing many flowers and fruits and has expressive representativeness in the arboreal layer, factors that make it an attractive option for reforestation in degraded areas destined for preservation (DUARTE **et al.**, 2020; AGUILAR **et al.**, 2023; FLORA DO BRASIL, 2023).

In the present research, we evaluate four components to produce substrates: pine bark, carbonized rice husk, coconut fiber and vermicompost, available as by-products or discarders by other industries. In view of the above, the aims of this research were to compare the development of seedlings of *Allophylus edulis* in nurseries, in different types and combinations of substrates.

MATERIAL AND METHODS

The experiment was developed in the nursery of the Brazilian Agricultural Research Company located in Colombo, Paraná (Embrapa Florestas) (25°19’18” S 49°09’34,4” O). According to the International System of Köeppen the climate is Cfb (humid subtropical climate). The seeds were collected from seven sites in the municipality of Bocaiúva do Sul, Paraná, and stored in a dry chamber at 14ºC ± 1ºC temperature and 38% ± 2% relative humidity.

Pure substrates or mixtures of commercial product based on pine bark and vermiculite (PBV), carbonized rice husk (CRH), granulated coconut fiber (GCF), mixed coconut fiber (MCF) and vermicompost (VC) were used in the following treatments: T1: 100% PBV; T2: 70% PBV + 20% CRH + 10% CV; T3: 70% PBV + 20% GCF + 10% VC and T4: 70% PBV + 20% MCF + 10% VC.

The substrate with pine bark and vermiculite had pine bark as the basic raw material and 17% expanded vermiculite relative to the percentage of bark volume. The coconut fiber had different particle sizes. The powder obtained after the mesocarp defibration generates the granulated coconut fiber, which presents a finer texture. The material that is retained in a 2 cm sieve corresponds to the fibrous coconut fiber and the mixture of these two materials constitutes the mixed coconut fiber.

A concrete mixer was used to mix the compounds and tubes of 100 cm³ were filled with the substrate on a vibrating table. Two seeds were used per tube and they remained for one month in a nursery with 50% shading and light spray. Subsequently the trays were transferred to a greenhouse for two weeks, and later moved to full sun.

Base and topdressing fertilization were performed according to Gonçalves *et al.* (2000) (Table 1). Base fertilization was added to the substrates and topdressing fertilization was started one month after the beginning of the experiment, biweekly for N and monthly for KCl.

TABLE 1 – Dosage, amount and fertilizer used in base fertilization and topdressing fertilization.

Fertilizing	Nutrient Dosage	Fertilizer	Amount (g)
Base (dose/m^3)	150 g N	Ammonium sulfate	600
	300 g P_2O_5	Simple superphosphate	1667
	100 g K_2O	Potassium chloride	167
	150 g micronutrients	micronutrients	150
Top-dressing	200 g N	Ammonium sulfate	800
	150 g K_2O	Potassium chloride	25

Source: Adapted from Gonçalves *et al.* (2000).

Height measurements were performed biweekly and stem diameter monthly, up to 135 days after emergence of seedlings. Height was measured by supporting the ruler in the growing tube until the apical point. Stem diameter was measured with a digital caliper positioned 1 cm from the base of the seedling.

Destructive analyzes were carried out on 12 medium height seedlings per treatment. Values for leaf area, root dry biomass, aerial part biomass and total biomass were measured at the Phytotechnology Laboratory (UFPR).

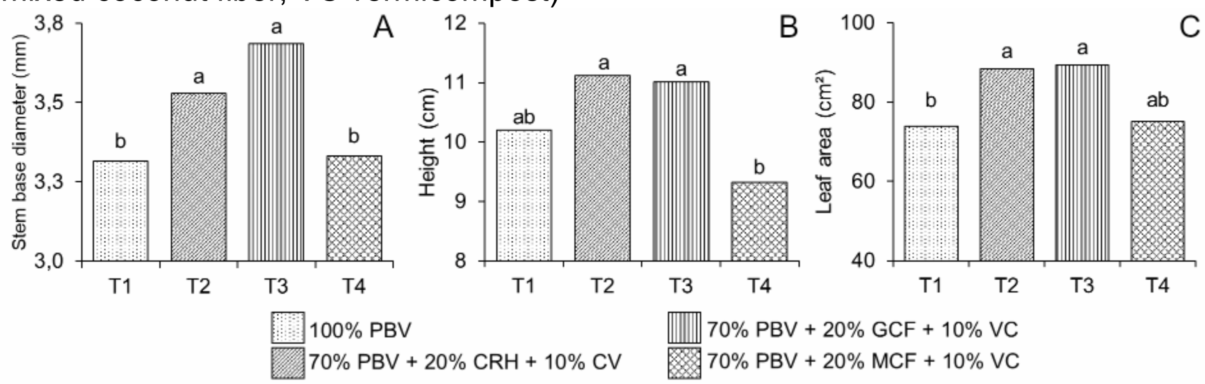
Leaf area and root morphological variables were obtained through an optical scanner coupled to the program Winrhizo Pro v. 2002c. The material was taken to a drying oven at 65° C for 72 hours to measure the dry biomass.

The experiment was distributed in randomized blocks, corresponding to six blocks. Each treatment had 8 seedlings per block, totaling 48 seedlings in each treatment, besides the border seedlings. Statistical analyses (tests for normality, ANOVA and Tukey test) were performed using Statgraphics Centurion software (version 15.1.02) with 99% and 95% confidence.

RESULTS AND DISCUSSION

Overall, our results showed that treatments T2 and T3 provided more satisfactory results for *A. edulis* seedlings growth. For stem base diameter, Tukey test indicated two distinct groups: treatments T2 and T3 presented a statistically superior result to treatments T1 and T4, at 95% confidence (ANOVA: $F = 14.44$; $p = 0.00$) (Figure 1A). Similarly, Tukey test also indicated that seedlings produced in treatments T2 and T3 presented superior results for height (ANOVA: $F = 7.40$; $p = 0.00$). However, T1 was placed in the intermediate position and T4 had the worst performance (Figure 1B). For leaf areas, treatments T2 and T3 are statistically superior, while treatment T4 was placed in an intermediate position (Figure 1C) and treatment T1 performed worst (ANOVA: $F = 4.81$; $p = 0.0056$).

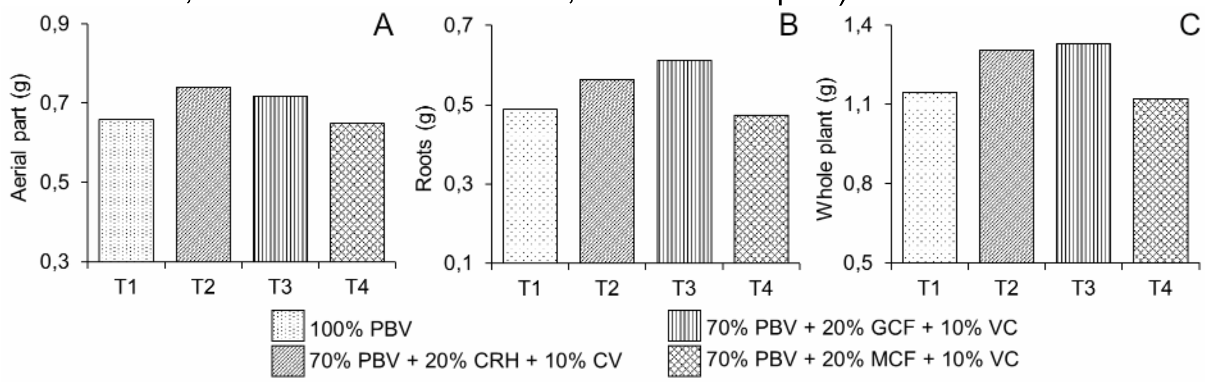
FIGURE 1 – *A. edulis* seedlings stem base diameter (mm) (A), height (cm) (B) and leaf area (cm²) (C) after 135 days of observation. Mean values followed by the same letter are not statistically different according to Tukey test ($p > 0.05$). (PBV: pine bark and vermiculite; CRH: carbonized rice husk; GCF: granulated coconut fiber; MCF: mixed coconut fiber; VC vermicompost)



Source: Authors (2020).

Conversely, dry biomass results did not show statistical differences between treatments. Similar results were obtained for dry biomass of the aerial parts (ANOVA: $F = 2.33$; $p = 0.09$), dry root biomass (ANOVA: $F = 3.03$; $p = 0.04$) and total biomass (ANOVA: $F = 3.09$; $p = 0.04$), where there was no statistical difference between the treatments, at 95% confidence (Figure 2ABC).

FIGURE 2 – *A. edulis* seedlings dry biomass of the aerial parts (g) (A); dry root biomass (g) (B); whole plant (total) biomass (g) (C), after 135 days of observation. ANOVA test did not reveal a significant difference between treatments ($p > 0.01$). (PBV: pine bark and vermiculite; CRH: carbonized rice husk; GCF: granulated coconut fiber; MCF: mixed coconut fiber; VC vermicompost)



Source: Authors (2020).

It should be noted that the leaf area and dry biomass of the aerial parts behaved differently: while for leaf area treatments T3 and T4 performed better, the treatments did not present statistical differences for dry biomass of the aerial parts. This fact could be explained by the thickness and density of the aerial parts of the seedlings. Treatments T1 and T4 probably produced higher density and/or leaf thickness than treatments T2 and T3, thus resulting in similar values in terms of dry biomass. According to Boeger and Wisniewski (2003), characteristics of smaller leaf area, greater stomatal density and greater total thickness may be due to several processes during plant formation, such as seasonal water deficiencies, low nutrient contents and protection of leaf longevity.

Treatment T1 was composed only of pine bark and vermiculite, a substrate commonly used in commercial nurseries, while the other treatments were formulated by adding different materials in different proportions to this commercial substrate. According to Higashikawa *et al.* (2010), pine bark substrates present an acidic pH, around 4.26, and low nutritional levels, and mixtures should be used to improve its properties and reduce the electrical conductivity, providing better conditions for the seedling development. Thus, a better performance of such mixed substrates would be expected, since the added materials improved the original conditions and produced seedlings of better quality. However, this was not observed with the combination used in treatment T4 treatment, where mixed coconut fiber and vermicompost were added to the commercial substrate. Therefore, this substrate was not satisfactory to produce *A. edulis* seedlings under the conditions observed.

Treatments T3 and T4 differed in their compositions only by the granulometry of the coconut fiber: granulated (fine texture) and mixed (fibrous and granulated fiber, thicker texture), respectively. The substrate containing granulated coconut fiber performed better than the substrate with mixed fiber, likely because it provided better aeration and drainage conditions. The distribution of particle size is an important characteristic that informs the properties such as air and water capacities, bulk density and others for optimum plant growth in containers (BANITALEBI *et al.*, 2019).

According to Minami (1995) the carbonized rice husk, component of treatment T2, presents characteristics such as pH close to neutral, abundance of minerals, mainly Ca, K and Si, low cation exchange capacity, low moisture retention capacity and is free of pathogens due to the carbonization process. In the same way, Silva *et al.* (2012), studying substrates for seedling production of *Eucalyptus urophylla* x *E. grandis*, concluded that the addition of carbonized rice husk conferred lower density to the substrate, resulting in higher porosity. The use of this material in the substrate composition can reduce the seedlings production costs, since the rice bark can be obtained for lower prices in comparison to the commercial substrate (LANG; BOTREL, 2008).

Granulated coconut fiber, used in treatment T3, presented satisfactory results in this experiment. The physical structure of this component is important for the final formation of the seedlings, considering that the coconut fiber compounds present high water holding capacity, besides containing important nutrients to seedling development (MARIYAPPILLAI; ARUMUGAM; 2020; MASQUELIER, 2022). Santos *et al.* (2014) observed that treatments formulated with coconut fiber, carbonized rice husk and *in natura* offered higher levels of K and Ca when added to the substrate. It is also necessary to consider that these macronutrients are required throughout both the vegetative and reproductive growth of the plants and should be represented in balanced amounts (HAWKESFORD *et al.*, 2023).

CONCLUSIONS

The substrates composed of 70% pine bark and vermiculite, 20% carbonized rice husk and 10% vermicompost, and 70% pine bark and vermiculite, 20% granulated coconut fiber and 10% vermicompost are more effective for the growth of *A. edulis* seedlings. Stem base diameter, height, and leaf area of *A. edulis* seedlings showed statistically significant differences between the treatments. Dry biomass of aerial parts, dry root biomass, and total biomass did not show statistical differences between the treatments. The granulometry of coconut fiber affects the aeration and drainage conditions of the substrate.

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REFERENCES

AGUILAR, M. V. M.; KUINCHTNER, C.C.; WERTONGE, G.S.; BIRCK, T.P.; PEIXOTO, T.W. *et al.* Tolerance and sensitivity of Inga marginata and *Allophylus edulis* to copper excess. **Trees**, p. 1-16, 2023. Available at: <https://link.springer.com/article/10.1007/s00468-022-02383-0>. doi: 10.1007/s00468-022-02383-0.

BANITALEBI, G.; MOSADDEGHI, M.R.; SHARIATMADARI, H. Feasibility of agricultural residues and their biochars for plant growing media: Physical and hydraulic properties. **Waste Management**, v. 87, p. 577-589, 2019. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0956053X19301059>. doi: 10.1016/j.wasman.2019.02.034.

BOEGER, M. R. T.; WISNIEWSKI, C. Comparação da morfologia foliar de espécies arbóreas de três estádios sucessionais distintos de floresta ombrófila densa (Floresta Atlântica) no Sul do Brasil. **Revista Brasileira de Botânica**, v. 26, n. 1, p. 61-72, 2003. Available at: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-84042003000100007>. doi: 10.1590/S0100-84042003000100007.

CHANG, R.; GUO, Q.; PANDEY, P.; LI, Y.; CHEN, Q.; SUN, Y. Pretreatment by composting increased the utilization proportion of pig manure biogas digestate and improved the seedling substrate quality. **Waste Management**, v. 129, p. 47-53, 2021. Available at: <https://www.sciencedirect.com/science/article/abs/pii/S0956053X21002828>. doi: 10.1016/j.wasman.2021.05.010

DUARTE, C.I.; MARTINAZZO, E.G.; BACARIN, M.A.; COLARES, I.G. Seed germination, growth and chlorophyll a fluorescence in young plants of *Allophylus edulis* in different periods of flooding. **Acta Physiologiae Plantarum**, v. 42, n. 80, 2020. Available at: <https://link.springer.com/article/10.1007/s11738-020-03063-7>. doi: 10.1007/s11738-020-03063-7

FARIA, J.C.T.; LOPES, D.A.; LYRA, G.B.; MELO, H.C. Manejo da densidade de plantas durante a produção de mudas em viveiro. **Ciência florestal**, v. 29, p. 1187-1198, 2019. Available at:

<https://www.scielo.br/j/cflo/a/8DBx8vjbBJJvmgwNsf6tNNQ/?lang=pt&format=html>. doi: 10.5902/1980509830030.

FLORA DO BRASIL. **REFLORA - Plantas do Brasil: Resgate Histórico e Herbário Virtual para o Conhecimento e Conservação da Flora Brasileira**. Available at: <http://reflora.jbrj.gov.br>. Accessed in: 12 Feb. 2023.

GONÇALVES, J. L. M.; SANTARELLI, E.G.; NETO, S.P.; MANARA, M. Produção de mudas de espécies nativas: substrato, nutrição, sombreamento e fertilização. In: J.L.M. GONÇALVES; V. BENEDETTI (eds.). **Nutrição e fertilização florestal**. IPEF, 2000. p. 310-350.

HAWKESFORD, M. J.; CAKMAK, I.; COSKUN, D.; DE KOK, L.J.; LAMBERS, H. *et al.* Functions of macronutrients. In: RENGEL, Z.; CAKMAK, I.; WHITE, P.J. (eds.). **Marschner's Mineral Nutrition of Plants**. Academic press, 2023. p. 201-281. Available at: <https://www.sciencedirect.com/science/article/abs/pii/B9780128197738000198>. Doi: 10.1016/B978-0-12-819773-8.00019-8.

HIGASHIKAWA, F. S.; SILVA, C. A.; BETTIOL, W. Chemical and physical properties of organic residues. **Revista Brasileira de Ciência do Solo**, v. 34, n. 5, p. 1743-1752, 2010. doi: 10.1590/S0100-06832010000500026 Available at: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-06832010000500026>. doi: 10.1590/S0100-06832010000500026.

LACERDA, A. E. B.; HANISCH, A. L.; NIMMO, E. R. Leveraging traditional agroforestry practices to support sustainable and agrobiodiverse landscapes in Southern Brazil. **Land,** v. 9, n. 6, p. 176, 2020. Available at: <https://www.mdpi.com/2073-445X/9/6/176>. doi: 10.3390/land9060176

LANG, D. Z.; BOTREL, M. C. G. Desenvolvimento de mudas de *Eucalyptus grandis* Hill ex Maiden em diferentes substratos. **Cultivando o Saber**, v. 1, n. 1, p. 107-117, 2008. Available at: <https://www.fag.edu.br/upload/revista/cultivando_o_saber/58fe57561d1aa.pdf>.

LIMA FILHO, P.; LELES, P.S.S.; ABREU, A.H.M.; SILVA, E.V.; FONSECA, A.C. Produção de mudas de *Ceiba speciosa* em diferentes volumes de tubetes utilizando o biossólido como substrato. **Ciência Florestal**, v. 29, p. 27-39, 2019. Available at: <https://www.scielo.br/j/cflo/a/z9FpRt6xnf4qYNFyk5rhDKJ/abstract/?lang=pt>. doi: 10.5902/1980509819340.

MARIYAPPILLAI, A.; ARUMUGAM, G. Physico-chemical and hydrological properties of soilless substrates. **Journal of Environmental Biology**, v. 42, n. 3, p. 700-704, 2021. Available at: <http://doi.org/10.22438/jeb/42/3/MRN-1504>. doi: 10.22438/jeb/42/3/MRN-1504.

MASQUELIER, S.; SOZZI, T.; BOUVET, J.C.; BÉSIERS, J.; DEOGRATIAS, J.M. Conception and Development of Recycled Raw Materials (Coconut Fiber and Bagasse)-Based Substrates Enriched with Soil Microorganisms (Arbuscular Mycorrhizal Fungi, *Trichoderma* spp. and *Pseudomonas* spp.) for the Soilless Cultivation of Tomato (*S. lycopersicum*). **Agronomy**, v. 12, n. 4, p. 767, 2022.

Available at: <https://www.mdpi.com/2073-4395/12/4/767>. doi: 10.3390/agronomy12040767.

MINAMI, K. **Produção de mudas de alta qualidade em horticultura**. TA Queiroz, 1995.

SANTOS, F. E. V.; KUNZ, S. H.; CALDEIRA, M. V. W.; AZEVEDO, C. H. S.; RANGEL, O. J. P. Características químicas de substratos formulados com lodo de esgoto para produção de mudas florestais. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 8, n. 9, p. 971-979, 2014. Available at: <http://www.scielo.br/scielo.php?pid=S1415-43662014000900014&script=sci_abstract&tlng=pt>. doi: 10.1590/1807-1929/agriambi.v18n09p971-979.

SEMPER-PASCUAL, A.; BURTON, C.; BAUMANN, M.; DECARRE, J. GAVIER-PIZARRO, G. *et al.* How do habitat amount and habitat fragmentation drive time-delayed responses of biodiversity to land-use change?. **Proceedings of the Royal Society B**, v. 288, n. 1942, p. 20202466, 2021. Available at: <https://royalsocietypublishing.org/doi/full/10.1098/rspb.2020.2466>. doi: 10.1098/rspb.2020.2466

SILVA, R. B.; SIMÕES, D.; SILVA, M. R. Qualidade de mudas clonais de *Eucalyptus urophylla x E. grandis* em função do substrato. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v. 16, n. 3, p. 297-302, 2012. doi: 10.1590/S1415-43662012000300010 Available at: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1415-43662012000300010>. doi: 10.1590/S1415-43662012000300010.