

SCIENTIFIC ARTICLE

Controlled release fertilizer used for the growth of *Campomanesia aurea* seedlings

Aquélis Armiliato Emer^{1*}, Mara Cíntia Winhelmann¹, Marília Tedesco¹,
Claudimar Sidnei Fior¹, Gilmar Schafer¹

Abstract

Campomanesia aurea is a sub-shrub species native to the Pampa Biome, popularly known as “guabirobinha-do-campo”. It has an ornamental potential for use in pots or gardens due to its small size, irregular shape, intense flowering and aroma. One of the main factors for production is an adequate use of fertilizers and balanced fertilizations. The objective was to evaluate the growth of seedlings and nutrient leaf accumulation of *C. aurea* submitted to doses of controlled release fertilizer (CRF). *C. aurea* seedlings were transplanted to containers containing composted pinus bark and CRF doses of 0, 2.5, 5.0, 7.5 and 10.0 g L⁻¹. Height, chlorophyll index, number of stems, base diameter, leaf area, Dickson Quality Index, shoot dry matter, root dry matter and nutrient leaf accumulation were evaluated. For height, base diameter and number of stems, the point of maximum response was at the concentration 6.8, 6.6 and 6.9 g L⁻¹ CRF, respectively. For shoot dry matter, leaf area and chlorophyll, we verified increase up to the concentration 8.1, 7.8 and 8.0 g L⁻¹, respectively. There was a positive quadratic behavior for most nutrients, with the exception of Cu and Mn, which linearly increased with the increase of fertilizer dose. The application of CRF on *C. aurea* seedlings between 7 and 8 g L⁻¹ substrate promoted an increase on the main growth characteristics of ornamental importance and provides superior results on nutrient leaf content.

Keywords: Myrtaceae, native ornamental, nutrient leaf accumulation.

Resumo

Fertilizante de liberação controlada no crescimento de mudas de *Campomanesia aurea*

Campomanesia aurea é uma espécie sub-arbustiva nativa do Bioma Pampa, conhecida popularmente com guabirobinha-do-campo. Apresenta potencial ornamental para uso em vasos ou jardins devido ao seu pequeno tamanho, forma irregular, floração intensa e aromática. Um dos principais fatores para a produção é o uso adequado de fertilizantes e adubações equilibradas. O objetivo foi avaliar o crescimento de mudas e o conteúdo de nutrientes nas folhas de *C. aurea* submetidas a doses de fertilizante de liberação controlada (FLC). Mudas de *C. aurea* foram transplantadas para embalagens contendo casca de pinus compostada e as dose de FLC de: 0, 2,5; 5,0; 7,5 e 10,0 g L⁻¹. Avaliou-se a altura, índice de clorofila, número de ramificações, diâmetro de colo, área foliar, Índice de Qualidade de Dickson, massa seca da parte aérea, massa seca de raiz e acúmulo de nutrientes nas folhas. Para altura, diâmetro de coleto, número de hastes, o ponto de máxima resposta foi com a concentração de 6,8; 6,6; e 6,9 g L⁻¹ de FLC, respectivamente. Para a massa seca da parte aérea, área foliar e índice de clorofila verificaram-se aumentos até a concentração 8,1; 7,8 e 8,0 g L⁻¹, respectivamente. Houve comportamento quadrático positivo para a maioria dos nutrientes, com exceção de Cu e Mn, que foi linear crescente com o aumento da dose de fertilizante. A aplicação de FLC em mudas de *C. aurea* entre 7 e 8 g de substrato L⁻¹ promoveu um aumento nas principais características de crescimento de importância ornamental e proporciona resultados superiores no acúmulo de nutrientes nas folhas.

Palavras chave: Myrtaceae, Ornamental nativa, acúmulo de nutrientes nas folhas.

Introduction

Campomanesia aurea O. Berg is a sub-shrub species native to the Pampa Biome belonging to the Myrtaceae family, popularly known as “guabirobinha-do-campo”. This species develops in clumps. It has several stems with a height of usually less than one meter (Reitz, 1977). It

has an ornamental potential for use in pots or gardens due to its small size, irregular shape, intense flowering and aroma (Stumpf, 2009). Flowering extends from October to January (Reitz, 1977; Lorenzi, 2006).

The tendency of using and valuing native flora species as ornamental plants faces some obstacles, among them the lack of quality of seedlings available for commercialization.

¹ Universidade Federal do Rio Grande do Sul (UFRGS), Faculdade de Agronomia, Departamento de Horticultura e Silvicultura, Porto Alegre-RS, Brazil. *Corresponding author: aquelis_emer@hotmail.com

One of the main factors for production is an adequate use of fertilizers and balanced fertilizations, which allow a fast development of plants and their technical and economic viability (Floss, 2011). However, this information is scarce for most native species.

The amount of nutrients added to the substrate for production is one of the main factors to be taken into account at seedling early development (Lana et al., 2010). The most common forms of fertilizer application in nurseries are by using periodic fertigation or basic fertilization with solid fertilizers with a high solubility and/or controlled release. Some studies have demonstrated the greater efficiency of controlled release fertilizers when compared to soluble fertilizers for the production of seedlings of *Bauhinia forficata* (Behling, 2013), *Guazuma ulmifolia*, *Croton floribundus*, *Peltophorum dubium*, *Gallesia integrifolia* and *Myroxylon peruiferum* (Morais Neto, 2003).

Controlled release fertilizers have a varied longevity influenced by the coating material and mainly by environment humidity and temperature, whose rise lead to an increase release of nutrients (Dole and Wilkins, 2005). This characteristic is relevant for the production of seedlings, especially for slow-growing species. It guarantees nutrition and avoids nutrient loss during cycles, since the nutrient absorption capacity of the plant, among other factors, also varies according to temperature and water availability. Temperature affects permeability of cell membranes, which may be changed from a fluid to a gel-crystalline state, affecting ion absorption and cellular respiration, while water availability is responsible for solubilizing and transporting ions to roots (Kerbaui, 2013).

Nutritional requirements vary widely according to species. Nutrient concentration in plant tissues also varies, among other factors, according to climatic conditions and physiological stages. The leaf best represents the nutritional state of the plant and may be used to verify whether the nutrient applied to the soil or substrate has been efficiently absorbed by the plant (Floss, 2011).

In this context, it is important to know the correct dose for each species, avoiding phytotoxicity due to excessive use and also decreases in seedling growth due to lack of available nutrients (Gomes and Paiva, 2013). Studies on controlled release fertilizers have not been found for the genus *Camponesia*. Thus, the objective of this study is to evaluate the growth of seedlings and the nutrients leaf accumulation of *C. aurea* submitted to doses of controlled release fertilizer.

Materials and Methods

The experiment was conducted in an agricultural greenhouse. We used plants obtained from seeds collected in Barão do Triunfo, RS (30°18'136" S and 51°50'282" W), which has a Cfa climate (humid temperate) with hot summers, according to the Köppen classification. The relief of the collection site varies from wavy to strongly-wavy.

The experimental design was randomized blocks, evaluating four doses of a controlled release fertilizer and a control treatment, with four replications, and each plot consisted of eight plants.

The fruits were collected from approximately 50 matrices, and kept under laboratory conditions for about three days to soften the pulp and remove the seeds. Seeds were removed from fruits manually, and washed under tap water to remove the pulp. Immediately after seeds extraction, 72-cell expanded polystyrene trays (50 cm³) were seeded using commercial peat-based substrate. After approximately 60 days of sowing, seedlings containing 2 to 3 pairs of leaves were transplanted into black polyethylene packages with a 2 L capacity containing composted Pinus bark and different fertilization treatments.

The substrate had a dry density of 438 kg m⁻³, total porosity of 64.70%, electrical conductivity 1:5 (EC) of 0.51 mS cm⁻¹, and a pH (H₂O) of 6.69. For the treatments, we used the commercially available controlled release fertilizer covered by elastic polymer which, according to the manufacturer's information, contains 16% of total N (8.6% N in ammoniacal form and 7.4% N in the nitric form), 8% of P₂O₅, 12% of K₂O, 2% of MgO, 12% of SO₄, 0.02% of B, 0.05% of Cu, 0.4% of Fe, 0.06% of Mn, 0.015% of Mo and 0.02% of Zn, with a particle size of 2-4 mm and an effective duration of 8-9 months.

The doses were zero (control), 2.5, 5.0, 7.5 and 10.0 g L⁻¹ mixed to the substrate before filling the containers. The fertilization mix in the substrate and the filling of plastic packages were performed manually. No cover fertilization was performed. The irrigation was performed by drip irrigation and managed throughout the experiment according to the plants' needs, visualized by monitoring daily the substrate humidity.

The average temperature during the conduction of the experiment was obtained from Automatic Meteorological Institute of the National Institute of Meteorology (INMET) for the city of Porto Alegre (Figure 1).

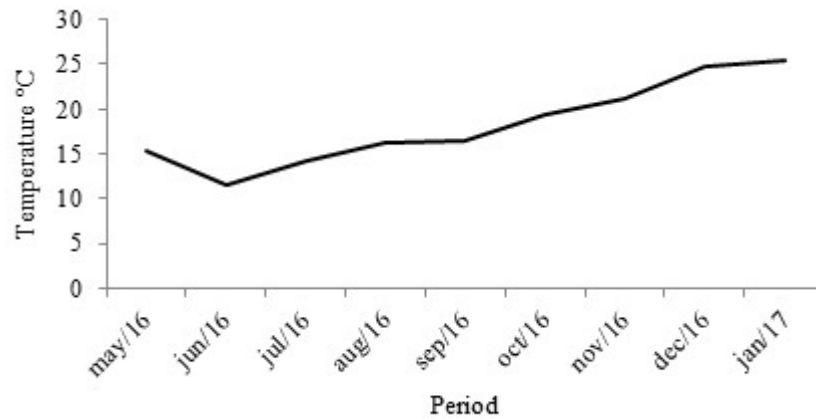


Figure 1. Average temperature (°C) of Porto Alegre, RS, obtained from the station of the National Institute of Meteorology (INMET), during the conduction the experiment in agricultural greenhouse.

At 270 days (9 months) after transplantation, seedling height, number of stems, base diameter, leaf area, Dickson quality index (DQI), chlorophyll index, root dry matter and shoot dry matter were evaluated. To determine plant height, a millimeter ruler was used, measuring the distance from the base to the apical bud. The Falker chlorophyll index (FCI) was measured using a ClorofiLOG® CFL1030 chlorophyll meter, with four readings distributed at different plant heights in fully expanded leaves, using the central part the leaves.

The stems originating from the main stem were considered ramifications, and the diameter was determined at the base of the plant using a digital caliper (0.01 mm). Leaf area was determined by separating all leaves from of the all stems presents in the plants, using the equipment LI-3100C. For the determination of dry matter, shoots were separated from the root system, packed separately in paper bags for oven drying at 65°C until constant weight, and then weighed in a semi-analytical balance.

The Dickson Quality Index (DQI) was calculated using the following formula:

$$DQI = \frac{TDMW}{\frac{H}{BD} + \frac{SDMW}{RDMW}}$$

Where:

TDMW - Total Dry Matter Weight (g)

H - Shoot Height (cm)

BD - Base Diameter (mm)

SDMW - Shoot Dry Matter Weight

RDMW - Root Dry Matter Weight

After determining dry matter, all leaves were sent to the laboratory to determine the concentrations of nitrogen (N) (Kjeldahl), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), copper (Cu), zinc (Zn), iron (Fe), manganese (Mn) (nitro-perchloric wet digestion), and boron (B) (dry digestion), using the equipment ICP-OES as described in (Tedesco et al., 1995).

The data were submitted to analysis of variance (ANOVA) and, when significant ($p < 0,05$), the means were analyzed by regression ($p < 0,05$).

Results and Discussion

We verified by regression analysis that, for the height of *C. aurea* seedlings, the maximum response point was concentration of 6.8 g L⁻¹ of the controlled release fertilizer, with a height estimated at just over 25 cm (Figure 2A). For *Eugenia uniflora*, a species of the same family, seedling height increased further when the doses 3 and 9 g L⁻¹ of slow release fertilizer were used (Elli et al., 2013). For *E. involucrata*, there was a response in height up to the highest dose of the tested controlled release fertilizer, 12 g L⁻¹ (NPK 18:05:09) (Rorato et al., 2016).

For the genus *Eucaliptus*, also belonging to the family Myrtaceae, the responses to the application of controlled release fertilizer vary according to species. For the seedling height of *E. dunnii*, the maximum technical efficiency concentration was 5.26 g L⁻¹ (NPK 19:06:10) for 110 cm³ controlled release fertilizer tubes (Navroski et al., 2016). This was similar to that observed for *E. urophylla* × *E. grandis*, which complied with the quality standard stipulated for the genus, between 20-35 cm high, from the dose of 4 g L⁻¹ of fertilizer (NPK 19:06:10), regardless of the substrate used (Silva et al., 2013). However, for *Eucaliptus saligna*, concentrations between 1.6 and 1.8 g L⁻¹ (NPK 15:10:10) were sufficient to reach the highest heights (Lana et al., 2010).

Shoot height is considered one of the most important parameters to estimate the initial growth of seedlings in the field, but it may present variations depending on the species and the production methods used in the nursery. Therefore, it should be combined with other parameters, such as base diameter and production of dry matter, to better estimate their quality (Gomes and Paiva, 2013).

For the number of stems and base diameter, the maximum response point was reached at the concentrations 6.9 and 6.6, respectively, producing 4.5 stems with a mean base diameter of 3.7 mm (Figure 2B and 2C). In the case of *C. aurea*, number of stems and base diameter are relevant because they result in a more compact and maintain the stems erects, respective, providing a more interesting visual effect to plants for ornamental use.

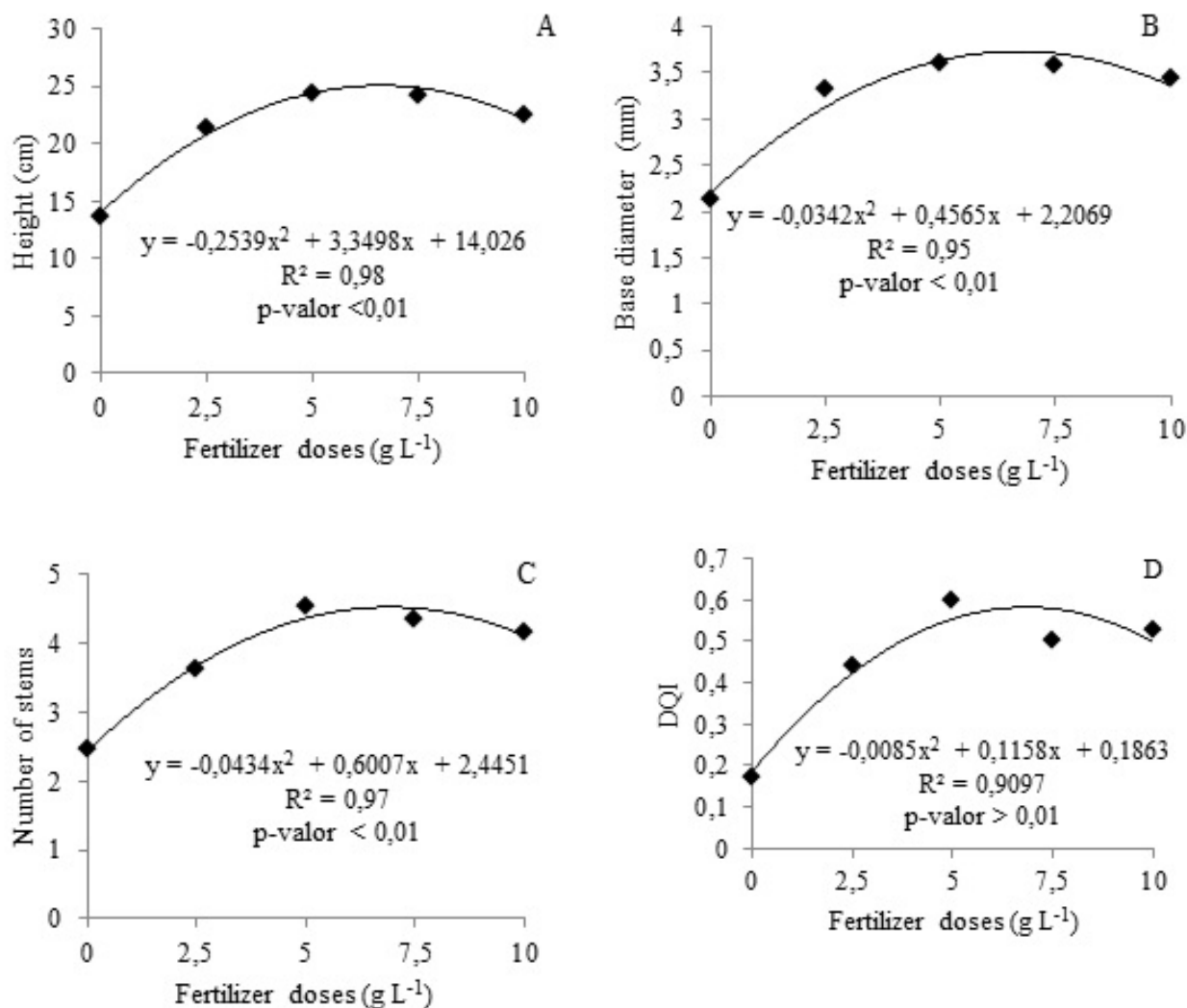


Figure 2. Height (A), base diameter (B), number of stems (C) and Dickson Quality Index (DQI) (D) of seedlings of *Campomanesia aurea* subjected to different doses of controlled release fertilizers, at 270 days after transplantation.

For *Eugenia uniflora*, the dose 3 g L⁻¹ provided the best results for base diameter (Elli et al., 2013). Already to *E. involucrata*, there was a greatest growth in stem diameter when using the dose 9 g L⁻¹ of controlled release fertilizer (Rorato et al., 2016). For *Eucalyptus urophylla* x *E. grandis*, the greatest base diameter was found at a controlled release fertilizer concentration of approximately 6 g L⁻¹ (Silva et al., 2013), similar to that found for *E. dunnii*, where the maximum technical efficiency dose was 5.42 g L⁻¹ for the 110 cm³ tube and 6.63 g L⁻¹ for the 55 cm³ tube (Navroski et al., 2016).

The use of controlled release fertilizer also provided increase on the shoot and root dry matter of *C. aurea*.

For shoot dry matter, the concentration 8.1 g L⁻¹ provided highest results, whereas for root dry matter, the fertilizer presented increase up to 6.2 g L⁻¹ (Figure 3A and 3B). A similar result was observed for *Eucalyptus urophylla* x *E. grandis*, where the highest shoot and root dry matter production occurred at the concentrations 8.0 and 5.4 g L⁻¹ of slow release fertilizer, respectively (Silva et al., 2013), and for *E. dunnii*, where concentrations greater than 5 g L⁻¹ caused a reduction in root length (Navroski et al., 2016). Similarly, another study on this same species reported an increase of up to 53% in shoot dry matter by increasing the fertilizer dose from 2 to 8 g L⁻¹, and by only 33% for root dry matter (Silva et al., 2014).

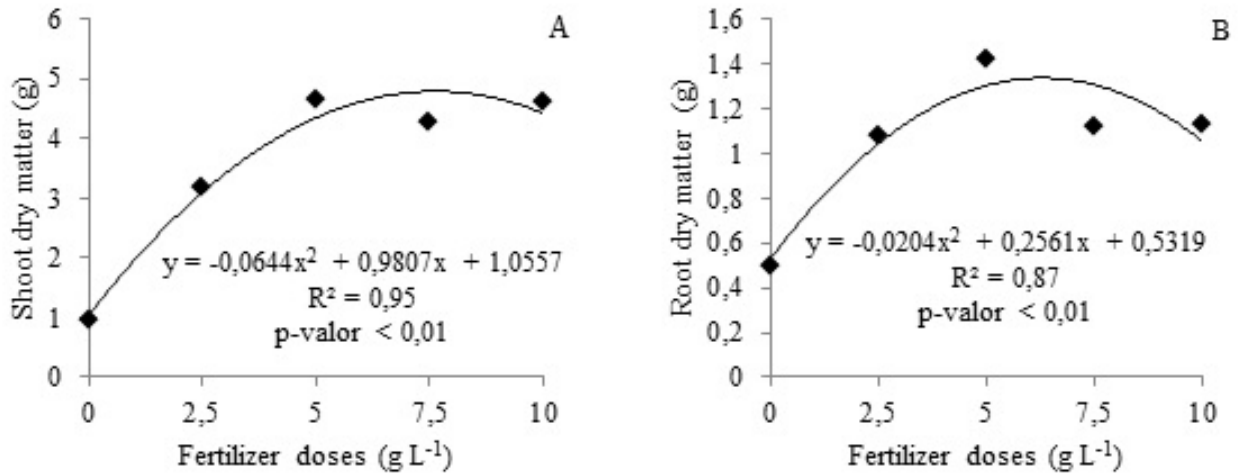


Figure 3. Shoot dry matter (A) and root dry matter (B) of seedlings of *Campomanesia aurea* subjected to different doses of controlled release fertilizers, at 270 days after transplantation.

Roots are the organs in direct contact with the substrate and fertilizers incorporated into the soil. They are more predisposed to be affected by this environment than plant shoots (Silva et al., 2013) in case of a nutritional imbalance or over-fertilization. This information corroborates with the results found in this study, in which the dose of maximum efficiency for the growth of shoots was higher than that verified for the root system. However, it is important to emphasize that, in case of nutritional imbalance, lack or excess of nutrients; both the shoot and the root systems are impaired.

The combination of height, base diameter and production of dry matter provides information on the quality standard of seedlings (Gomes and Paiva, 2013). Thus, DQI data are similar between these variables: doses higher than 7 g L⁻¹ cause a decrease in development (Figure 2D).

For leaf area, we verified increase up to the estimated dose of 7.8 g L⁻¹ (Figure 4A), close to that verified for shoot dry matter (8.1 g L⁻¹). Leaf area may be used as a parameter to estimate plant growth, as it is related to photosynthesis,

respiration and accumulation of dry matter by plants. The interception of light has an almost linear increase due to the increase in leaf area, to the point that mutual shading becomes limiting (Kerbaui, 2013).

The photosynthetic capacity of plants, besides leaf area, also depends on the chlorophyll content, which is the main photosynthetic pigment responsible for the absorption of light photons, mainly of blue and red wavelengths (Kerbaui, 2013). Plants with a low chlorophyll a/b ratio are more efficient in capturing light, since this ensures that the plant may better take advantage of solar radiation at moments when it is not so intense, possibly resulting in a higher photosynthetic rate (Cancellier et al., 2011).

In this sense, we observed that the chlorophyll a/b ratio was close to 3, regardless of treatment, which suggests a proportional increase in both chlorophylls with the addition of fertilizer up to approximately 8.0 g L⁻¹, when the values of 28.8 for chlorophyll a, 10.1 for chlorophyll b and 38.9 for total chlorophyll were estimated (Figure 4B, 4C and 4D).

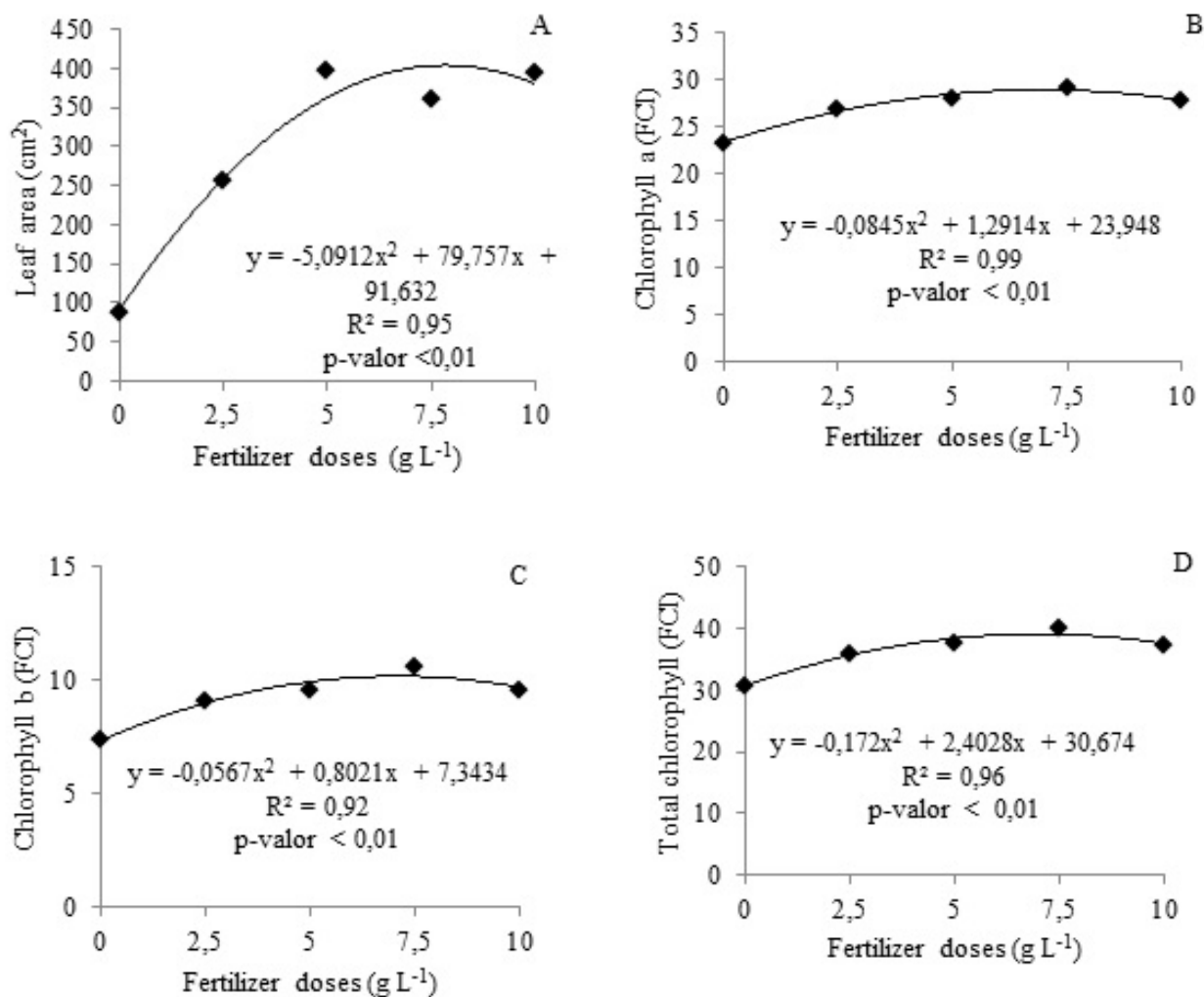


Figure 4. Leaf area (A), Falker chlorophyll index a (B), b (C) and total (D) of *Campomanesia aurea* seedlings subjected to different doses of controlled release fertilizers, at 270 days after transplantation.

For *Eugenia uniflora*, the chlorophyll content increased with the increase in doses of slow release fertilizer (Elli et al., 2013). However, for *Apuleia leiocarpa*, there was a quadratic behavior; concentrations above 6.32 g L⁻¹ exerted negative effects on the chlorophyll index (Pias et al., 2013). Chlorophyll deficiency results in a decrease in photosynthetic intensity, which contributes to the results observed in this study, in which concentrations of controlled release fertilizer close to 8 g L⁻¹ were the most efficient for *C. aurea* seedling growth, since they provided a greater shoot dry matter, a greater leaf area and greater indexes of chlorophyll a and b.

Chlorophyll synthesis depends on genetic, light and nutritional factors, especially N, Mg and Fe, since the first two are part of its molecule and the latter is a constituent of the enzyme that acts on the metabolism of N (Floss, 2011). There was an increasing quadratic behavior of N in plants with an increasing concentration of fertilizer up to 8.2 g L⁻¹, similar to that verified for chlorophyll content (8.0), although no correction was found between these factors (Figure 5A). Mg and Fe had a behavior similar to that observed for N, however, the maximum accumulation were observed at estimated doses at 5.9 and 6.5 g L⁻¹, respectively (Figure 5E and 6C).

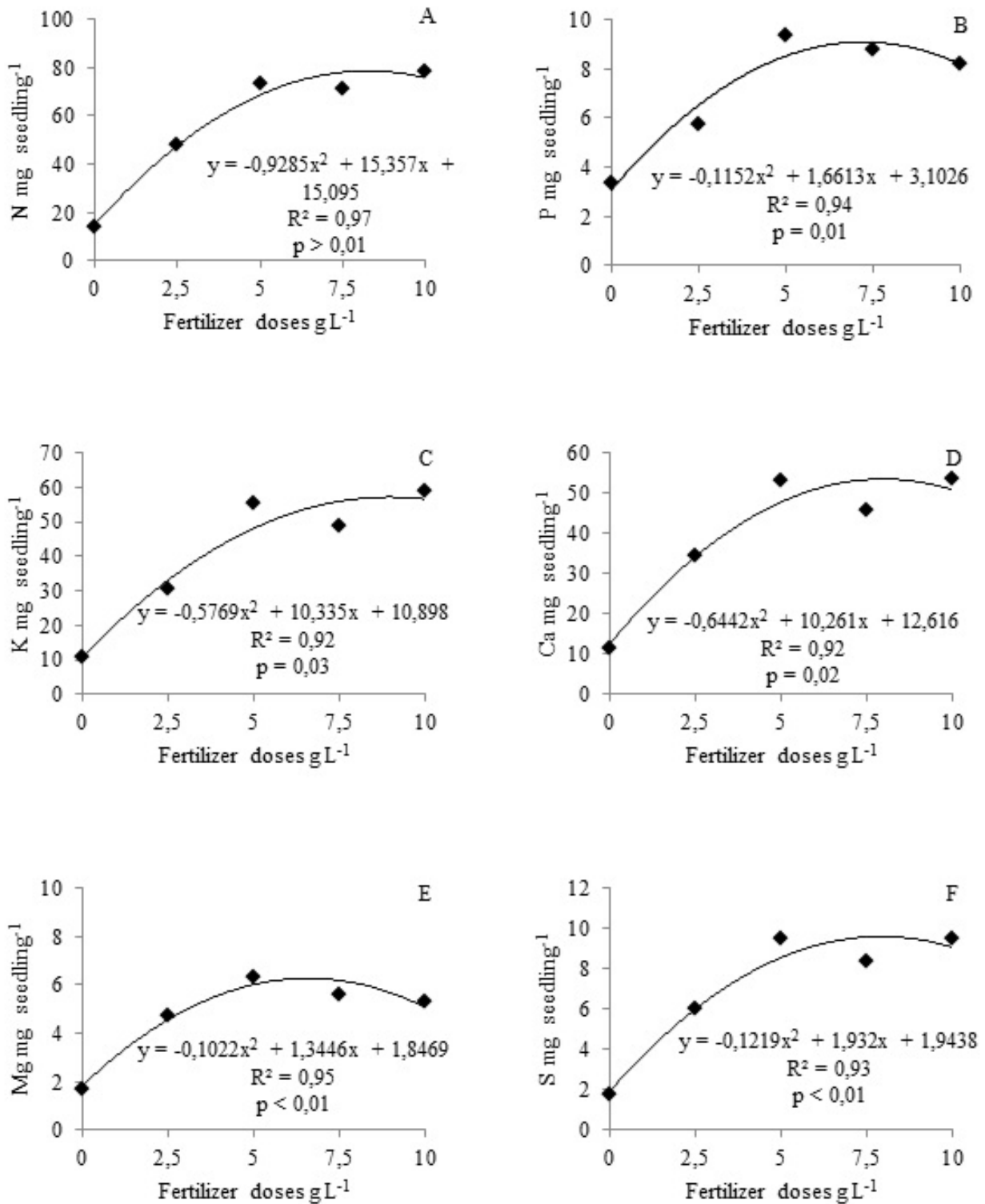


Figure 5. Macronutrients leaf content in *Campomanesia aurea* seedlings subjected to different doses of controlled release fertilizers, at 270 days after transplantation. Nitrogen (A), phosphorus (B), potassium (C), calcium (D), magnesium (E), sulfur (F).

For the other elements, the maximum accumulation in plants for P (7.2 mg L⁻¹) (Figure 5B), K (8.9 mg L⁻¹) (Figure 5C), Ca (7.9 mg L⁻¹) (Figure 5D), S (7.9 mg L⁻¹) (Figure 5F), Zn (8.3 mg L⁻¹) (Figure 6B) and B (7.1 mg L⁻¹) (Figure 6E) were similar to those observed

for shoot dry matter, leaf area and chlorophyll content. The growth rate of plants in function of any chemical element basically follows the same pattern: the zone of deficiency, by which plant growth increases considerably as the element is supplied in a greater quantity; the

adequate zone, by which the increase in nutrient does not significantly affect growth, represents the luxury consumption by the plant, by which storage occurs in the vacuoles of the element, comprising a relatively

broad range for macronutrients and more restricted for micronutrients; and the toxic zone, by which a great increase in any element leads to toxicity and reduces growth (Salisbury and Ross, 2012).

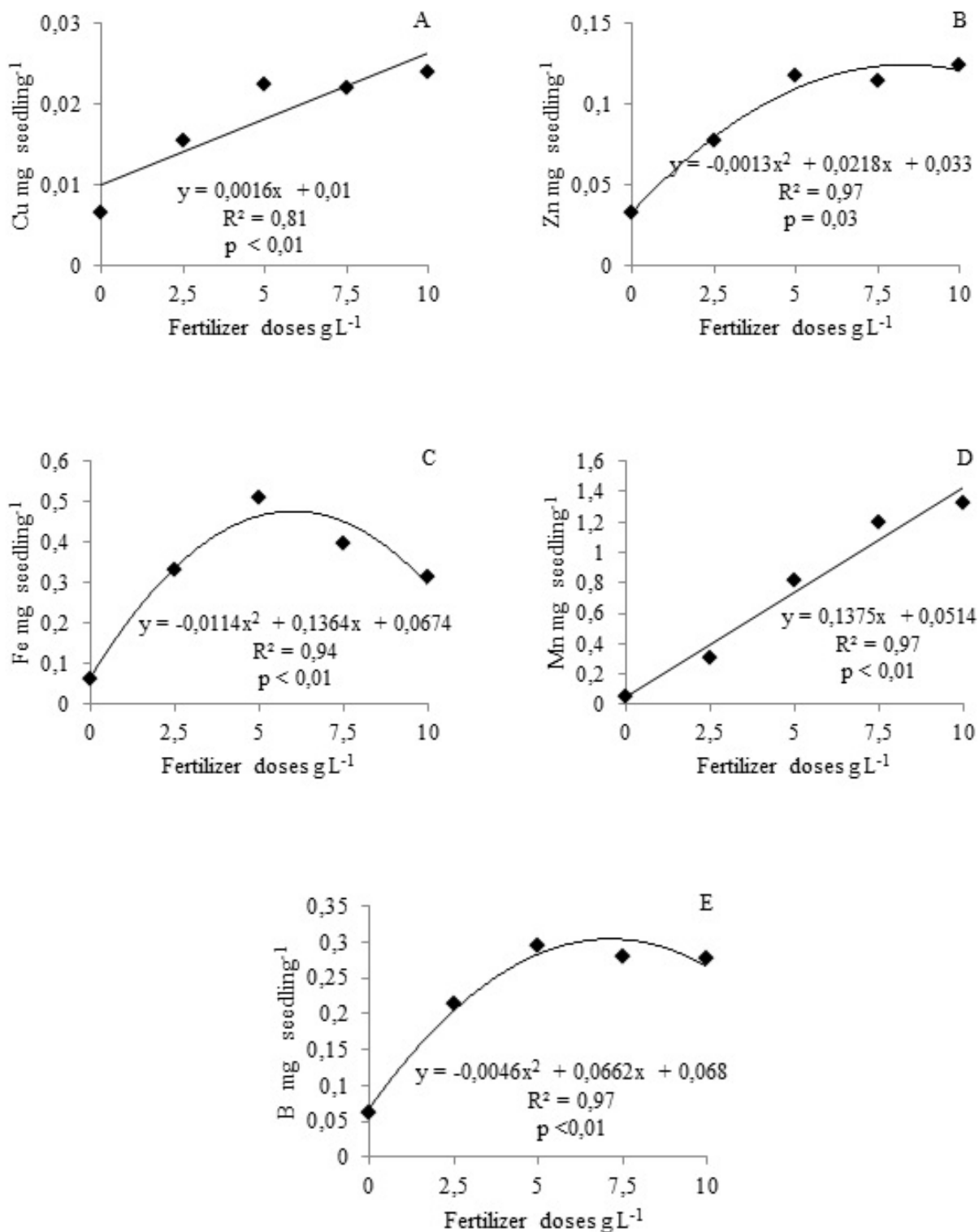


Figure 6. Micronutrients leaf content in *Campomanesia aurea* seedlings subjected to different doses of controlled release fertilizers, at 270 days after transplantation. Copper (A), zinc (B), iron (C), manganese (D) and boron (E).

Thus, based on the data obtained in this study, Cu and Mn (Figure 6A and 6D) would be the only nutrients that could exist at higher concentrations in the leaf tissue if they are available at high concentrations in the substrate, since they present an increasing linear behavior. However, Mn, independent of the applied dose, is at a concentration in the leaf tissue considered suitable for the majority of crops, unlike Cu, which was below the necessary concentration (Floss, 2011; Salisbury and Ross, 2012). The low concentration of Cu found in plants may be related to the low amount of fertilizer supplied, which is an ally of the substrate and may have caused a limited availability of the nutrient, since this nutrient is strongly adsorbed by organic matter (Kerbaux, 2013).

For *Parapiptadenia rigida*, the highest dose of controlled release fertilizer (12 g L⁻¹) was responsible for the highest concentration of nutrients in plant shoots. However, doses higher than 9 g L⁻¹ caused a decrease in most morphological characteristics evaluated. Thus, for this species, the concentrations of leaf nutrients that provided the highest growth rate were 20.25, 1.64, 8.00, 5.08, 2.70 and 1.12 g kg⁻¹ of N, P, K, Ca, Mg and S, respectively. As for micronutrients, the concentrations were 16.53, 2.98, 58.26, 60.90 and 29.71 mg kg⁻¹ of B, Cu, Fe, Mn and Zn, respectively (Gaparín et al., 2015).

Most native species grow on low fertilized soils, and their nutritional demands are low when compared to cultivated species, evidencing a good competitive capacity in their natural habitat (Salisbury and Ross, 2012). However, it is possible to accelerate the development of such species using an increased availability of nutrients, as observed for *C. aurea*, where increases were observed in all variables analyzed when using controlled release fertilizer in relation to the control. This information reinforces the importance of fertilization studies, as well as the determination of adequate doses in order to maximize technical efficiency, allowing the optimization of resources related to production costs, reducing the time of plants in nurseries, and the rational use of fertilizers.

Conclusions

The application of controlled release fertilizer on *Campomanesia aurea* seedlings between 7 and 8 g L⁻¹ substrate promoted an increase on the main growth characteristics evaluated of ornamental importance and provides increased results on nutrient leaf accumulation.

Author Contributions

A.A.E. ⁰⁰⁰⁰⁻⁰⁰⁰²⁻⁹⁹⁴⁴⁻³⁴⁶³: Responsible for the implementation, evaluation and writing of the article; **M.C.W.** ⁰⁰⁰⁰⁻⁰⁰⁰³⁻³⁴³¹⁻⁹⁴⁴²: assisted in the implementation and evaluation of the experiment; **M.T.** ⁰⁰⁰⁰⁻⁰⁰⁰²⁻³²⁸¹⁻⁹⁸³³: assisted in the implementation and evaluation of the experiment; **C.S.F.** ^{0000-0001-9893-081X}: assisted in the preparation of the study and correction of the article; **G.S.** ⁰⁰⁰⁰⁻⁰⁰⁰³⁻¹⁴²²⁻⁵⁰⁵¹: assisted in the preparation of the study and the correction of the article.

Acknowledgements

The authors are grateful to Capes (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior), CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) and FAPERGS (Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul) for the funding for the research.

References

- BEHLING, A.; PERRANDO, E.R.; BAMBERG, R.; SANQUETTA, C.R.; NAKAJIMA, N.Y. Efeito da nutrição no crescimento de mudas de *Bauhinia forficata* Link. **Interciencia**, v.38, n.2, p.139-144, 2013.
- CANCELLIER, E.L.; BARROS, H.B.; KISCHEL, E.; GONZAGA, L.A.M.; BRANDÃO, D.R.; FIDELIS R.R. Eficiência agrônômica no uso de nitrogênio mineral por cultivares de arroz de terras altas. **Revista Brasileira de Ciências Agrárias**, v.6, n.4, p.650-656, 2011. DOI: <http://dx.doi.org/10.5039/agraria.v6i4a1420>
- DOLE, J.M.; **Floriculture**: Principles and species. 2ed. Upper Saddle River: Prentice Hall, 2005. 1023p.
- ELLI, E.F.; CARON, B.O.; MONTEIRO, G.C.; PAVAN, M.A.; PEDRASSANI, M.; CANTARELLI E.B.; ELOY, E. Osmocote® no desenvolvimento e comportamento fisiológico de mudas de pitangueira. **Comunicata Scientiae**, v.4, n.4, p.377-384, 2013.
- FLOSS, E.L. **Fisiologia das plantas cultivadas: o estudo que está por trás do que se vê**. 5ed. Passo Fundo: Universidade de Passo Fundo, 2011. 734p.
- GASPARIN, E.; ARAUJO, M.M.; SALDANHA, C.W.; TOLFO, C.V. Controlled release fertilizer and container volumes in the production of *Parapiptadenia rigida* (Benth.) Brenan seedlings. **Acta Scientiarum Agronomy**, v.37, n.4, p.473-481, 2015. DOI: <http://dx.doi.org/10.4025/actasciagron.v37i4.19528>
- GOMES, J.M.; PAIVA, H.N. **Viveiros florestais: propagação sexuada**. Viçosa: Ed. UFV, 2011. 116 p.
- KERBAUY, G.B. **Fisiologia Vegetal**. 2ed. Rio de Janeiro: Guanabara Koogan, 2013.
- MORAES NETO, S.P.; GONÇALVES, J.L.M.; RODRIGUES, C.J.; GERES, W.L.A.; DUCATTI, F.; AGUIRRE JR, J.H. Produção de mudas de espécies arbóreas nativas com combinações de adubos de liberação controlada e prontamente solúveis. **Revista Árvore**, v.27, n.6, p.779-789, 2003. DOI: <http://dx.doi.org/10.1590/S0100-67622003000600004>

- LANA, M.C.; LUCHESE, A.V.; BRACCINI, A.L. Disponibilidade de nutrientes pelo fertilizante de liberação controlada Osmocote e composição do substrato para produção de mudas de *Eucalyptus saligna*. **Scientia Agraria Paranaensis**, v.9, n.1, p.68-81, 2010. DOI: <http://dx.doi.org/10.1818/sap.v9i1.4289>
- LORENZI, H., BACHER, L., LACERDA, M., SARTORI, S. **Frutas brasileiras e exóticas cultivadas (de consumo in natura)**. São Paulo: Instituto Plantarum de Estudos da Flora, 2006. 640p.
- NAVROSKI, M.C.; NICOLETTI, M.F.; LOVATEL, Q.C.; PEREIRA, M.O.; TONETT, E.L.; MAZZO, M.V.; MENEGUZZI, A.; FELIPPE, D. Efeito do volume do tubete e doses de fertilizantes no crescimento inicial de mudas de *Eucalyptus dunnii* Maiden. **Revista Agrarian**, v.9, n.31, p.26-33, 2016.
- PIAS, O.H.C.; CANTARELL, E.B.; BERGHETTI, J.; LESCHEWITZ, R.; KLUGE, E.R.; SOMAVILLA, L. Doses de fertilizante de liberação controlada no índice de clorofila e na produção de mudas de grápia. **Pesquisa Florestal Brasileira**, v.33, n.73, p.19-26, 2013. DOI: <https://doi.org/10.4336/2013.pfb.33.73.419>.
- RORATO, D.G.; ARAUJO, M.M.; DUTRA, A.F.; TURCHETTO, F.; BERGHETTI, A.L.P.; MIETH, P. Effect of different container volumes and concentration of the controlled release fertilizer in the production of *Eugenia involucrata* DC seedlings. **African Journal of Agricultural Research**, v.11, n.46, p.4762-4767, 2016. DOI: <https://doi.org/10.5897/AJAR2016.11835>
- SALISBURY, F.B.; ROSS, C.W. **Fisiologia das plantas**. 4ed. São Paulo: Cengage Learning, 2012. 774 p.
- SILVA, R.B.G.; SIMÕES, D.; ANDRADE, F.R.; SILVA, M.R. Qualidade de mudas seminais de eucalipto em função dos substratos e fertilização de liberação controlada. **Interciencia**, v.38, n.3, p.215-220, 2013.
- SILVA, R.B.G.; SILVA, M.R.; SIMÕES, D.R. Substrates and controlled-release fertilizations on the quality of *Eucalyptus* cuttings. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.18, n.11, p.1124-1129, 2014. DOI: <http://dx.doi.org/10.1590/1807-1929/agriambi.v18n11p1124-1129>
- STUMPF, E.R.T. **Cores e formas no Bioma Pampa: plantas ornamentais nativas**. Pelotas: Embrapa Clima Temperado, 2009. 272 p.
- REITZ, P.R. **Flora ilustrada catarinense**. Itajaí: Herbário Barbosa Rodrigues, 1977.
- TEDESCO, M.J.; GIANELLO, C.; BISSANI, C.A.; BOHNEN, H.; VOLKWEISS, S.J. Análises de solo, plantas e outros materiais. UFRGS - Departamento de Solos, Porto Alegre, 1995.