Development of angelonia in pot below doses of slow-release fertilizer[1]

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ABSTRACT

Angelonia integerrima is a native species that has ornamental potential, being cultivated in flowerbeds, flowerpots, pots, or even used as a complement in floral arrangements. Knowledge of mineral nutrition is required for the cultivation of the species, and slow release fertilization have become widespread in recent years, with a lower risk of toxicity to crops, an economy in relation to complementary fertilizers and may be an alternative to cultivation of potted plants. The aim of this study was to evaluate the development of *Angelonia integerrima* Sprengel in pot under slow release fertilization doses. Acclimatized seedlings with approximately 1 cm height, from *in vitro* germinated seeds were transplanted into 1 L pots containing substrate composted *Pinus* bark. Five doses of Basacote ® 9M slow release fertilizer, formulation 16-8-12 (N - P_2O_5 - K_2O), 9 months: control - 0 g L^{-1}, 2.5 g L^{-1}, 5.0 g L^{-1}, 7.5 g L^{-1} and 10.0 g L^{-1}. The plants were grown in a greenhouse under drip irrigation. The shoot length, length of the largest inflorescence, number of stems, diameter of the largest stem, mean length of the stems, number of open flowers, fruits and senescent flowers, chlorophyll *a*, *b* and total, mass of dry matter of shoot and root system were evaluated after 286 days. The experimental design was completely randomized, with four replicates of six pots per plot. Data were submitted to analysis of variance (ANOVA) followed by polynomial regression by SigmaPlot 11.0. It was possible to adjust a quadratic equation for the variables: shoot length (with maximum response point in 7.2 g L^{-1}), mean length of stems (6.7 g L^{-1}), diameter of the largest stem and the root system (5.9 g L^{-1}), number of open flowers, buds, senescent flowers and total flowers (7.7 g L^{-1}). For the variables, number of stems, number of fruits, chlorophyll *a*, *b* and total did not differ between treatments. The slow releaser fertilizer indicated dose for the cultivation of the potted species is 7.2 g L^{-1}.

Keywords: *Angelonia integerrima*, basacote, pampa biome, mineral nutrition, native ornamental.

RESUMO

Desenvolvimento de angelônia em vaso, sob doses de adubo de liberação lenta

Angelonia integerrima é uma espécie nativa que possui potencial ornamental podendo ser cultivada em canteiros, floreiras, vasos, ou ainda ser utilizada como complemento em arranjos florais. Para o cultivo da espécie são requeridos conhecimentos sobre nutrição mineral e os adubos de liberação lenta têm-se difundido nos últimos anos, já que apresentam menor risco de causar toxicidade às culturas, economia com relação a adubações complementares e podem ser uma alternativa para o cultivo de plantas em vaso. Diante disso, o objetivo do trabalho foi avaliar o desenvolvimento de *Angelonia integerrima* Sprengel em vasos, sob doses de adubo de liberação lenta. Mudas oriundas de sementes germinadas *in vitro,* com aproximadamente 1 cm de altura foram aclimatizadas e, posteriormente transplantadas para vasos de 1L contendo substrato de casca de *Pinus* compostada. Foram utilizadas cinco doses do fertilizante de liberação lenta Basacote® 9M, formulação 16-8-12 (N - P_2O_5 - K_2O: controle - 0 g L^{-1}, 2,5 g L^{-1}, 5,0 g L^{-1}, 7,5 g L^{-1} e 10,0 g L^{-1}. As plantas foram cultivadas em casa de vegetação sob irrigação por gotejamento e, após 286 dias de cultivo, foram avaliados comprimento da parte aérea, comprimento da maior inflorescência, número de hastes, diâmetro da maior haste, comprimento médio das hastes, número de flores abertas, botões, frutos e flores senescentes, clorofila *a*, *b* e total, massa da matéria seca da parte aérea e do sistema radicular. O delineamento experimental foi inteiramente casualizado, com quatro repetições de seis vasos por parcela. Os dados foram submetidos à análise de variância (ANOVA) seguido de regressão polinomial pelo SigmaPlot 11.0. Foi possível ajustar uma equação quadrática para as variáveis: comprimento da parte aérea (com ponto de máxima resposta em 7,2 g L^{-1}), comprimento médio das hastes (6,7 g L^{-1}), diâmetro da maior haste (6,4 g L^{-1}), massa da matéria seca da parte aérea (7,8 g L^{-1}) e do sistema radicular (5,9 g L^{-1}), número de flores abertas, botões, flores senescentes e total de flores (7,7 g L^{-1}). Já para as variáveis, número de hastes, número de frutos, clorofila *a*, *b* e total não diferiram entre os tratamentos. A dose indicada para o cultivo da espécie em vaso é de 7,2 g L^{-1} do adubo de liberação lenta.

Palavras-chave: *Angelonia integerrima*, basacote, bioma pampa, nutrição mineral, ornamental nativa.

DOI: http://dx.doi.org/10.14295/oh.v24i4.1164

[1] Received in 01/03/2018 and accepted in 08/10/2018

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1. INTRODUCTION

The genus *Angelonia* grows wild in the neotropical region, from central Mexico to the southern tip of South America (BOFF et al., 2014). The precise location of its origin is not fully understood (PLASCHIL and OLBRICHT 2008; GOSCH et al., 2014). The approximately 50 species (TROPICOS, 2017) have different shapes and flower colors, which vary between blue, violet, white, and pink (GOSCH et al., 2014).

Angelonia integerrima Sprengel is commonly called angelonia or violeta-do-campo (violet-of-the-field). This species is herbaceous and perennial, stands up to 40 cm high, and grows in rocky outcrops and stony fields. The stem has a burgundy hue, with simple, oblong, and opposite leaves. The flowers, which bloom between October and March, are arranged in racemes of white to light lilac color, with some purple hue. This species has ornamental potential and can be cultivated in flowerbeds, flowerpots, and vases, as well as used as a complement in flower arrangements (STUMPF et al., 2009).

In order to be able to cultivate this species, studies about its mineral nutrition are needed, because the agricultural practice of fertilization requires detailed knowledge, for rational use of fertilizers (ARAÚJO et al., 2009), and this knowledge comes from research. Despite their great potential, many native Brazilian species have not yet been domesticated or even explored for possible use and cultivation. Thus, research is important to exploit such native species as new cultivation options. Compared to other commercial crops, floriculture is a relatively recent activity; thus, the information available on mineral nutrition required by ornamental plants is still limited (FURTINI NETO et al., 2015), and for cultivation of native species, the information is even more limited.

Slow-release fertilizers are incorporated into the substrate, with less risk of causing toxicity and economy advantages than the complementary fertilizers. The speed that nutrients are released depends on the humidity of the medium and the temperature (BELLÉ, 2008). Slow-release fertilizers have been widely used in recent years and are an important alternative to cultivate ornamental plants in flowerpots (BELLÉ, 2008).

The species *A. integerrima* has already been the focus of several studies (WINHELMANN et al., 2016; WINHELMANN et al., 2018a; WINHELMANN et al., 2018b), some of which is not yet published, but more information is needed on the viability of fertilization. Therefore, the objective of the study was to evaluate the development of *Angelonia integerrima* in vases, using different doses of slow-release fertilizer.

2. MATERIAL AND METHODS

Angelonia integerrima seeds were collected in an area of native vegetation, located in the municipality of Barão do Triunfo, RS, Brazil (30º 18 'S, 51º 50' W) in February 2015. The fruits were in transition from green to straw color, beginning natural dehiscence. After collection, the seeds were taken to the laboratory, and stored for 10 months in transparent glass bottles with snap caps in a refrigerator at temperature 5 ± 1 °C.

On December 2, 2015, *in vitro* germination of the seeds was carried out in Murashige and Skoog (1962) medium (MS). On February 10, 2016, the plants were acclimatized with approximately 1 cm shoot length, which were transferred to polyethylene trays, without division, containing commercial substrate Carolina Soil®. The trays were kept under irrigation by nebulization without temperature control and with relative humidity maintained above 90%.

On March 2, 2016, after the acclimatization of the seedlings, the fertilization experiment was installed. A composite pine bark was used as substrate, with a dry density of 438 kg m^{-3}, total porosity of 64.7%, electrical conductivity (1:5) of 0.51 mS cm^{-1} and pH (H_2O) of 6.7. Commercial Basacote® 9M slow-release fertilizer was used with formulation 16-8-12 (N - P_2O_5 - K_2O), which, according to the manufacturer's information, contained 16% total N, (8.6% N in ammoniacal form and 7.4% N in nitric form), 8% P_2O_5, 12% K_2O, 2% MgO, 12% SO_3, 0.02% B, 0.05% Cu, 0.4% Fe, 0.06% Mn, 0.015% Mo, 0.02% Zn, with granulometry of 2 to 4 mm and effective duration of 8 to 9 months, which was manually incorporated into the substrate.

Five treatments were used: control (0 g L^{-1}), T1 (2.5 g L^{-1}), T2 (5.0 g L^{-1}), T3 (7.5 g L^{-1}), and T4 (10 g L^{-1}). Seedlings with four expanded leaves were transplanted to flowerpots with 1 L capacity, which were kept on a bench in a greenhouse, under a drip irrigation system, managed daily, according to the needs of the plants.

At the end of the experimental period, on December 12, 2016, at 286 days, we analyzed the length of shoot and largest inflorescence; number of stems; diameter of largest stem; mean length of stems; number of open flowers, buds, fruits, and senescent flowers; chlorophyll *a*, *b*, and total; and dry mass of the shoot and root system.

The length of the plant shoots was obtained with a millimeter ruler. The diameter of the largest stem was obtained with the aid of a digital caliper. The number of open flowers, buds, fruits, and senescent flowers was manually counted. The chlorophyll index of the leaves was evaluated using an electronic chlorophyll meter (chlorofiLOG), model CFL1030 from Falker®, which uses the Falker Chlorophyll Index (FCI) as the unit of measurement, a dimensionless index. Four leaves per plant were randomly chosen to determine values of *a*, *b*, and total chlorophyll. The root system was washed in tap water to remove the substrate, and then, in the same manner as the shoot, it was oven dried at 65 ± 5 °C until constant weight.

The experimental design was completely randomized, with four replicates of six plants per plot. Data were submitted to analysis of variance (ANOVA) followed by polynomial regression by SigmaPlot 11.0. The data on shoot length, mean length of stems, and chlorophyll *b* did not meet the normality assumptions and therefore were transformed to log (x/10), the number of stems transformed to Asen (root/10) and the dry shoot mass was transformed to the inverse of the root.

3. RESULTS AND DISCUSSION

The data were submitted to analysis of variance. A quadratic equation was used to adjust the following variables: shoot length, mean length of stems, diameter of the largest stem, dry mass of shoot and root, as well as number of open flowers, buds, senescent flowers, and total flowers (Figure 1). No differences were found between treatments for the variables: number of stems, number of fruits, and chlorophyll *a*, *b*, and total.

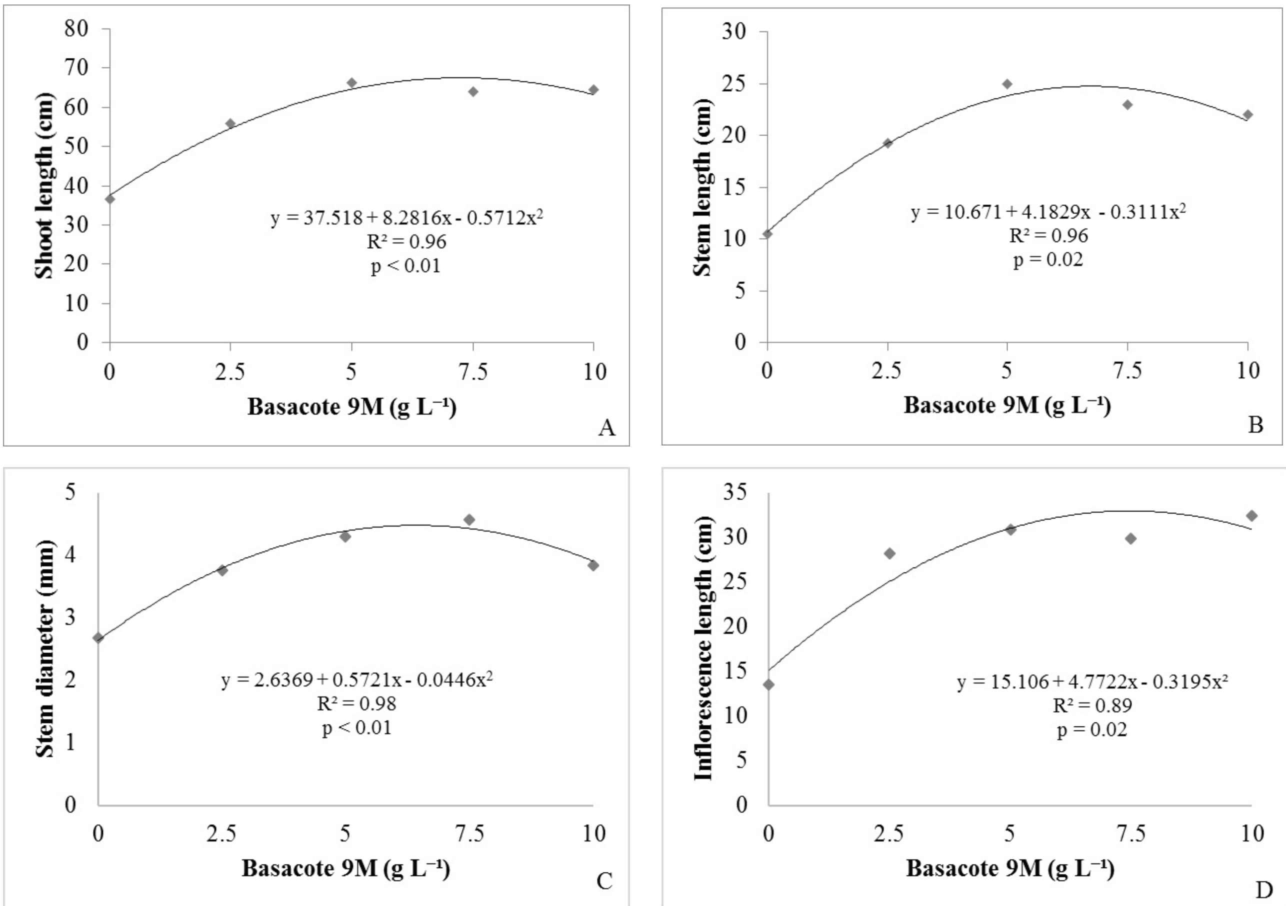

Figure 1. Shoot length (A), stem length (B), stem diameter (C), inflorescence length (D) of *Angelonia integerrima* as a function of different doses of Basacote 9 M.

According to the regression equation, the shoot length had a positive growth response, with fertilization up to the 7.2 g L^{-1} dose, reaching 67.5 cm (Figure 1A), which is well above the 40 cm described in the literature for plants in an *in situ* environment (STUMPF et al., 2009). The length and diameter of the stems showed a positive response to fertilization up to 6.7 and 6.4 g L^{-1}, with 24.7 cm length and 4.4 mm diameter, respectively (Figure 1B and 1C). When compared to an established crop species with similar characteristics and used as cut flower, such as snapdragon (*Antirrhinum majus* L.), which has a quality standard stipulated of 50 to 80 cm in stem length and 4 to 6 mm stem thickness (VEILLING HOLAMBRA, 2017), the stems of *A. integerrima* described herein would be within the commercialization standard, reinforcing the possibility of using the species also as cut flower.

Regarding the number of stems, no statistical differences were observed between the fertilization rates, with each plant possessing an average of 5.7 stems. The length of the inflorescence was stimulated by increased fertilization up to the dose of 7.4 g L^{-1}, presenting up to 32.9 cm (Figure 1D), which is more than that standardized for snapdragon between 8 and 12 cm (VEILLING HOLAMBRA, 2017). An estimation using the maximum efficiency dose for total flower production (7.7 g L^{-1}) reaches 114 flowers per inflorescence. This amount could be underestimated, as some of the flowers may already have spontaneously fallen or turned into fruits (Figure 2). This demonstrates the high production of flowers by this species, and its suitability both in gardens and cut flowers.

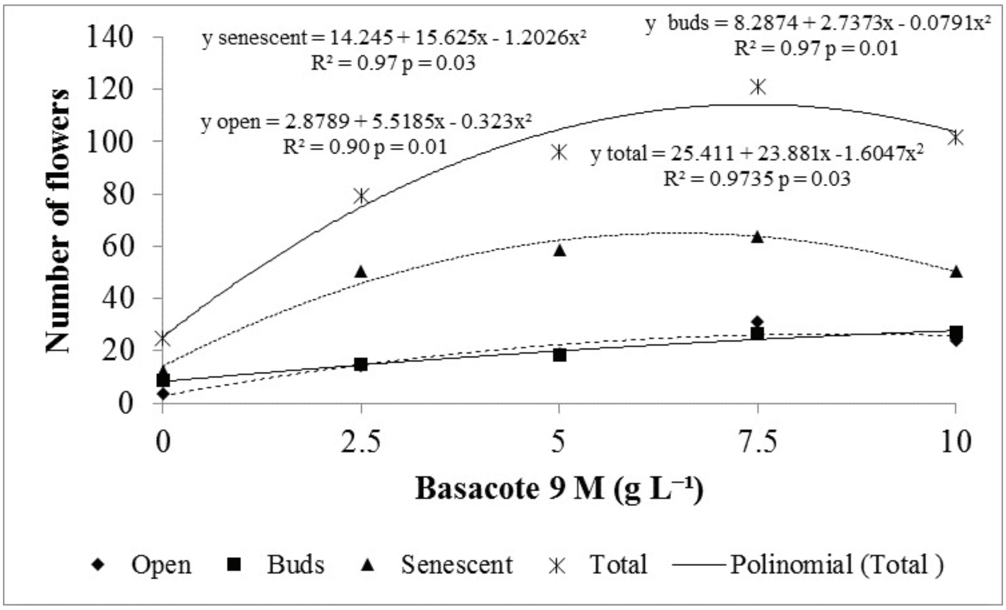

Figure 2. Number of open flowers, buds, senescent and total of *Angelonia integerrima* due to different doses of Basacote 9 M.

The dry shoot mass exhibited an increasing response up to 7.8 g L^{-1}, while dry root mass increased only up to 5.9 g L^{-1} (Figure 3A and 3B). Roots are in direct contact with the substrate and the fertilizers incorporated to it; thus, they are more predisposed to be compromised by this environment than the shoot of plants (SILVA et al., 2013). In another study with pineapple cv. Vitoria, the use of slow-release fertilizer had positive effects on height, number of leaves, and dry shoot mass up to the approximate dose of 4.3 g L^{-1}. However, they found a negative linear effect on the dry root mass (FREITAS et al., 2011), similar to that seen of *A. integerrima*.

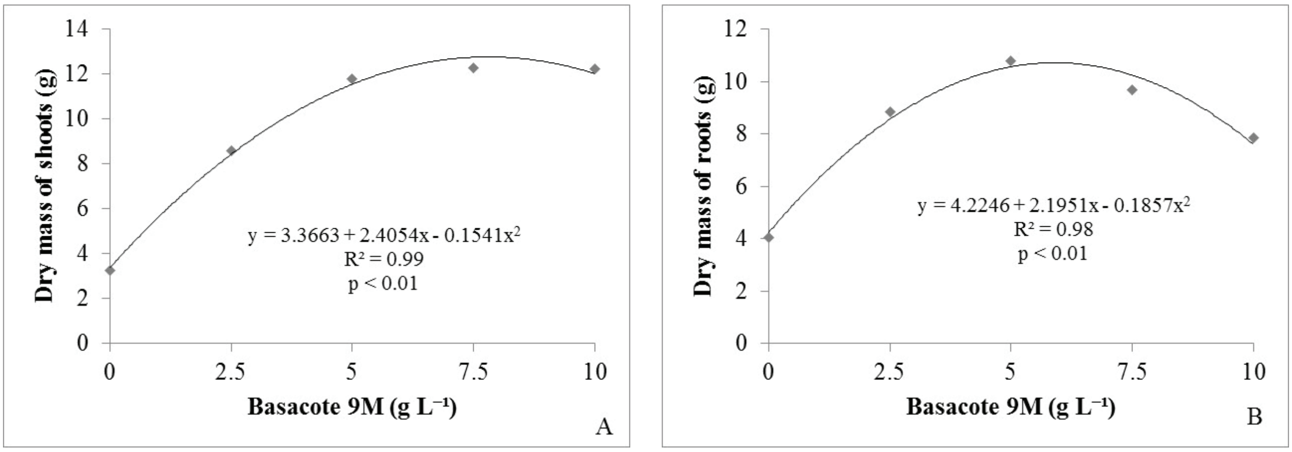

Figure 3. Dry mass of the shoots (A) and dry mass of the root system (B) of *Angelonia integerrima* due to different doses of Basacote 9 M.

Slow-release fertilizer had a positive effect on ornamental peppers (*Capsicum annuum*) for height, diameter, number of leaves and fruits at doses between 5.1 and 5.6 g L^{-1} (BACKES et al., 2007). An effect similar to that observed in the present work was found for black pepper (*Piper nigrum* L.), which showed positive responses until the doses 5.8, 6.8, and 6.0 g L^{-1}, respectively for height, stem diameter, dry shoot mass. (SERRANO et al., 2012).

For papaya (*Carica papaya* L.), the maximum efficiency dose for height, stem diameter, dry shoot and root mass was 15.2, 15.1, 10.9, and 10.1 g L^{-1}, respectively (MELO JÚNIOR et al., 2014), which is greater than those found in the present study. These variations could be due to the differences related to the growth characteristics of each species, the fertilizer formulations, the substrate properties, and the container used. Therefore, it is important to carry out this work.

For the Chlorophyll Falker indices, no differences were found between the fertilization rates, and the means were 32.73, 15.29, and 48.03 for chlorophyll *a*, *b*, and total, respectively (Table 1). The chlorophyll content is used to estimate the nutritional status of plants in relation to nitrogen (FLOSS, 2011), which is one of the most required mineral elements and limits plant growth the most (TAIZ et al., 2017). Although there were no differences in chlorophyll content, the plants showed typical symptoms of nitrogen deficiency, especially those that did not receive fertilization, as evidenced by the decrease in shoot growth, leaf and flower formation (KERBAUY, 2013), which collaborates with the data on dry mass and quantity of flowers found in the present study. The plant may have concentrated the nitrogen in the leaves to maintain the photosynthetic apparatus active, prioritizing its survival to the detriment of its vegetative and reproductive development. In addition, the organic origin of the substrate used may have contributed to nitrogen supply, but other elements may have been limited for the plants' development.

Table 1. Falker chlorophyll index *a*, *b* and total in *Angelonia integerrima* as a function of different doses of Basacote 9 M.

Doses	Chlorophyll *a*	Chlorophyll *b*	Chlorophyll total
0	30.76*	11.06*	41.82*
2.5	34.49	19.37	53.86
5.0	33.35	14.41	47.75
7.5	32.20	15.76	47.97
10.0	32.89	15.87	48.77
Average	32.73	15.29	48.03
CV	10.81	33.52	13.50

* Not significant by the Tukey test at the 5% error probability level. CV = coefficient of variation.

Although the species occurs naturally in rocky soils and stony outcrops (STUMPF et al., 2009), with possibly limited fertility, *A. integerrima* responds very well to fertilization with positive effects on the vegetation and flowering development, constituting characteristics suitable for use as cut or garden flowers.

4. CONCLUSIONS

The ideal dose for the development of *Angelonia integerrima* in a vase is 7.2 g of commercially available slow-release fertilizer Basacote® 9M with the formulation 16-8-12 (N - P_2O_5 - K_2O), which produced shoot length suitable for use as a cut flower.

ACKNOWLEDGMENTS

The authors are grateful to Capes (Coordination for the Improvement of Higher Education Personnel), CNPq (National Council for Scientific and Technological Development) and FAPERGS (Foundation for Research Support of the State of Rio Grande do Sul) for the funding for the research.

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M.C.W. 0000-0003-3431-9442: responsible for the implementation, evaluation and writing of the article, **A.A.E.** 0000-0002-9944-3463: assisted in the evaluation of the experiment and writing of the article. **M.T.** 0000-0002-3281-9833: assisted in the implantation and the evaluation of the experiment. **P.P.** 0000-0002-8314-8048: assisted in the implantation and the evaluation of the experiment. **C.S.F.** 0000-0001-9893-081X: co-adviser, assisted in the correction of the article. **G.S.** 0000-0003-1422-5051: adviser assisted in the preparation of the study and correction of the article.

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