PHILIPP AGRIC SCIENTIST
Vol. 100 No. 3, 258–262
September 2017

ISSN 0031-7454

Physiological and Growth Responses of *Begonia semperflorens* to Different Growing Media

Monica Popescu and Gheorghe Cristian Popescu*

University of Pitesti, Faculty of Sciences, Targu din Vale Street, No. 1, 110040, Pitesti, Romania (e-mail: monica_26_10@yahoo.com; christian_popescu2000@yahoo.com)

*Author for correspondence

Begonia plants are among the most popular ornamental plants that are very well suited for landscaping, flowerbeds, hanging baskets or container pots. Currently, in Romania, there has been an increasing demand to produce flowers for the landscaping market, and for the use of land in private and public gardens. Several organic and inorganic natural materials in different combinations were investigated for photosynthetic capacity, leaf area and flowering potential of *Begonia semperflorens*. The main objective of this study was to determine whether or not different growing media formulas are suitable for ornamental plant production with marketable value. Optimization of growing media formulas was performed by preparing four growing media mixing fallow soil, biolan peat, acid peat, leaf compost and perlite in different proportions. The highest photosynthesis rates as well as leaf area were obtained from growing media with 60% biolan peat, 30% acid peat and 10% perlite (BP60-AP30-P10). There were recorded results which suggest that begonias grown in the BP60-AP30-P10 medium seem to be high-value ornamental plants, while the ornamental value of the plants cultured in media containing fallow soil is too low.

Key Words: *Begonia semperflorens*, flowering potential, optimization, photosynthesis, substrates

INTRODUCTION

The *Begonias* are native to moist subtropical and tropical climates. Currently, numerous hybrid cultivars are grown for commercial production by farmers in different climatic regions all over the world. The flowers of *Begonia semperflorens* are among the most appreciated in the Romanian market for floricultural and ornamental plants. This sector of horticulture has had a significant growth over the past years, and presently shows positive trends, but the market is dominated by imports. This study aimed to promote the increase and diversification of ornamental plants from local production cultivated in different growing substrates.

Begonia is the sixth largest genus of flowering plants, with 1400–1500 species in 66 sections. *Begonia* x *semperflorens* – cultorum hort., a member of the family Begoniaceae, is a popular and widely cultivated ornamental plant (Stults and Axsmith 2011).

Growing media are used in horticulture for growing seedlings, plant propagation, and ornamental plant production, and these soilless substrates affect the ornamental value of potted plants. The response of plants to different substrates is strictly related to the tested species, and one of the most relevant aims of growing-media study is to identify the possible use of different organic and inorganic materials in ornamental plant production (García-Gómez et al. 2002; Grigatti et al. 2007; Rinaldi et al. 2014).

Many studies have reported on results of the use of growing media in ornamental plants such as *Pinus pinea*, *Cupressus arizonica* and *Cupressus sempervirens* (Hernández-Apaolaza et al. 2005), *Gerbera jamesonii* (Ahmad et al. 2012), rose (Fascella and Zizzo 2005), geranium, petunia, carnation and gerbera (Carmona et al. 2012), *Camellia japonica* (Larcher et al. 2011), *Begonia semperflorens*, *Salvia splendens*, and *Tagetes patula* × *erecta* (Grigatti et al. 2007). However, there has been no detailed study on the growth and physiological responses of *Begonia semperflorens* grown in Romania.

Different organic materials are increasingly used in horticulture, not only as a soil amendment and fertilizer, but also as a plant-growing medium. Many studies demonstrated that organic materials such as wood wastes, pruning waste, spent mushroom, pine bark, coconut fiber, animal manures, grape marc, grape stalk, peat, leaves compost used in different formulas and concentrations for the preparation of horticultural growing media have been found to improve soil properties and increase or maintain horticultural crop yields (Benito et al. 2005; Hicklenton et al. 2001; Chen et al. 2002; Hernández-Apaolaza et al. 2005; Hargreaves et al. 2008; De Lucia et al. 2013).

In order to promote ornamental plant technologies, a good knowledge of the effect of substrates related to physiological aspects is required. The optimization of potting growing media is necessary for high production, development of plant quality and environmental protection. Studies on growing substrates of Begonia proved to be of great importance in improving horticultural technology management related to plant physiological responses.

The aim of this research was to determine the influence of growing media on some physiological parameters, leaf area and flowering potential for *B. semperflorens*. We analyzed these parameters 3 mo after planting in order to reduce production time and cost by obtaining plants with decorative value capable of trading in the shortest time. In this experiment, we optimized the growth substrate composition of *B. semperflorens* in order to provide information on good agricultural practices to ornamental plant producers.

MATERIALS AND METHODS

Plant Material and Culture Conditions

The experiments were carried out in the laboratories and greenhouse of the University of Pitesti, Romania. The plant material tested and evaluated in this study is represented by *B. semperflorens* Link & Otto 'Asot F1'. Begonia plants used in this study are characterized by the following attributes: compact and well branched plants, uniformity of flower color, perfect for high density production and very well suited for use in landscaping and containers.

It is important to select an adequate growing medium to provide an essential tool for managing ornamental potted plants. Four growth substrates were prepared by mixing these growing media components in different percentages: 100% fallow soil (FS100); 30% biolan peat + 60% acid peat + 10% perlite (BP30-AP60-P10); 60% biolan peat + 30% acid peat + 10% perlite (BP60-AP30-P10); and 33% biolan peat + 33% leaf compost + 33% perlite (BP33-C33-P33). Leaf compost is an organic product which was prepared by fermentation of plant debris from gardens and deciduous forests. Acid peat has a pH around 4.2 and biolan peat is a natural resource usually with a pH around 6 (Biolan Oy, Kauttua, Finland). In Romania, fallow soil has a pH of around 6.8 and is often used as a component for growth substrates in horticulture; it is obtained from the top layer of the soil on fallow land with perennial grasses. In order to stimulate the rooting development system of each plant in the growth medium, the fertilizer Osmocote Exact (The Scotts Company Ltd., Godalming, Surrey, UK) was added when cuttings were planted**.** Cuttings from selected cultivars were planted in plastic pots (one plant per pot) with a diameter of 12 cm. The growing temperature in the greenhouse was 24 ± 2 °C. Twenty replicate pots per growth substrate were used.

Measurements

Photosynthetic capacity is an important indicator that explains the physiological activity of plants and the potential for vegetative development. As regards the assessment of the growth medium influence on plant physiological activity, we determined the effect of photosynthesis and the respiration rate (μmol CO_2 m^{-2} s^{-1}) in the leaves, the content of chlorophyll a (Chl a, mg g^{-1}) and chlorophyll b (Chl b, mg g^{-1}), the Chl a / Chl b ratio in the leaves, total leaf chlorophyll content (mg g^{-1}), carotenoids (Car, mg g^{-1}), and the Chl a+b / Car ratio.

Leaf gas exchange parameters were measured with a portable plant CO_2 analysis package (S151 Infrared CO_2 analyzer, Qubit Biology Inc., Ontario, Canada). Photosynthesis was measured in attached leaves maintained in an assimilation chamber. The CO_2 concentration was measured with an infrared gas analyzer (IRGA). The difference between the initial CO_2 concentration in the air and that in the air of the leaf chamber is used to measure the rate of photosynthesis. During the process of testing, the light level (PPFD) was 1800 μmol m^{-2} s^{-1}, the air temperature was 24 ± 2 °C and the ambient relative humidity was between 60% and 65%.

Leaves were collected early in the morning and transported in an ice box to the laboratory for later determinations of assimilatory pigment content. Photosynthetic pigments were extracted in 80% acetone. Absorbance at 662, 646 and 440.5 nm was determined using a BOECO S-20VIS spectrophotometer (Boeckel & Co, Hamburg, Germany). The amounts of chlorophyll and carotenoid pigments were calculated using Holm's formulas (Holm 1954).

The total chlorophyll content was calculated as the sum of Chl a and Chl b. The results were obtained as mg pigments g^{-1} fresh weight.

The effect of the proposed substrates was also evaluated by counting the number of leaves per plant. The measurements for photosynthetic capacity, number of leaves and leaf area were calculated at two major phenophases of plant life-cycle: the leafing and the flowering stage. The influence of growth substrates on flowering potential was expressed as the number of flowers per plant and leaf area/flowers ratio. The measurements in the leafing stage were recorded 4 wk after planting, while measurements in the flowering stage were recorded when plants gained ornamental value for selling 12 wk after planting.

Statistical Analysis

A statistical analysis was performed using the ANOVA in the SPSS 16.0 software (IBM Corporation, Armonk, New York, USA) and means were compared using Least Significant Difference (LSD) at 5% level. The results of this study are expressed as means.

RESULTS AND DISCUSSION

The results of the analysis regarding the effects produced by the growth substrates of *B. semperflorens* 'Asot F1' on photosynthesis and respiration rate μ molCO_2 m^{-2} s^{-1} are shown in Table 1. Begonias grown on media with 100% fallow soil had the lowest respiration and photosynthesis rates for both leafing and flowering stages. The respiration and photosynthesis rates were greatly influenced by the growth substrate with the BP60-AP30-P10 formula. No significant differences regarding the respiration rate of begonia plants were found between the BP60-AP30-P10 and BP33-C33-P33 horticultural growing media in the flowering stage and between BP30-AP60-P10 and BP33-C33 -P33 media in the leafing phase. Photosynthesis during the flowering stage showed significant differences between all growth media, but there were no significant differences between BP30-AP60-P10 and BP33-C33-P33 media in the leafing stage of begonias (Table 1). Carbohydrates synthesized in photosynthesis are strongly correlated with dry matter production and quality of foliage plant.

Many authors have investigated the photosynthetic capacity of numerous horticultural species (Nemali and Iersel 2004; Moccaldi and Runkle 2007; Oh et al. 2009). These results confirmed the findings of Borowski and Nurzynski (2012) who studied the rate of photosynthesis and photosynthetic pigment content in the leaves of tomato grown on horticultural growing media containing rape straw, triticale straw, pine bark and peat in different proportions.

Growth substrates which were used for *B. semperflorens* 'Asot F1' did not show significant differences in terms of chlorophyll a and chlorophyll b content between the BP30-AP60-P10 and BP33-C33-P33 media for both plant phenological phases. The observations recorded on chlorophyll a and b content indicated that the BP60-AP30-P10 growing substrate produced the highest content of chlorophyll pigments. The chlorophyll content increased by raising the amount of biolan peat and was negatively influenced by FS100 media. The content of chlorophyll a was higher than that of chlorophyll b, and the content of these pigments was more in the flowering than in the leafing stage of the plants.

The Chl a / Chl b ratio in the leaves of begonias showed higher values in growth media containing 60% biolan peat + 30% acid peat + 10% perlite (Table 2). Zhang et al. (2010) reported that two genotypes of *Begonia semperflorens* planted in pots containing a mixture of peat, vermiculite and perlite had no significant differences between red and green leaves in chlorophyll and carotenoid content and Chl a/b ratio. Morales-Corts et al. (2014) studied the effect of green and pruning wastes, vermicompost and slumgum compost incorporated in different combinations with commercial peat as growing media for *Rosmarinus officinalis* (rosemary), *Cupressocyparis leylandii* (Leyland cypress), *Petunia* x *hybrida* (petunia), and *Viola tricolor* (pansy). The authors determined the number of leaves, chlorophyll level of leaves, plant height and the number of flowers. They observed that in the case of leyland cypress, petunia and pansies, all substrate combinations in high proportion of green and pruning wastes compost showed good growth rates.

The horticultural growing media used in this experiment had a higher effect in the flowering phenological phase than in the leafing stage for total leaf chlorophyll content. Maximum chlorophyll content was observed in plants grown on BP60-P30-P10 media. Total leaf chlorophyll content (Table 3) in the flowering phase of begonia plants that were cultured on the BP30-AP60-P10 and BP33-C33-P33 media did not show any significant differences.

Regarding the influence of growth media on carotenoid pigments, there were no significant differences between applying the BP30-AP60-P10 medium and the BP33-C33-P33 medium, but we found significant differences between BP60-AP30-P10 media and other growth substrates for both phenological phases studied. The Chl a+b / Car ratio measured in the leaves was higher in the medium with BP60-AP30-P10 for leafing phase and also in the BP30-AP60-P10 media for flowering stage (Table 3).

The maximum vegetative growth potential shown by number of leaves per plant and leaf area was observed in plants grown in BP60-AP30-P10 medium, followed by the BP30-AP60-P10 medium (Table 4). B. semperflorens 'Asot F1' had the lowest number of leaves and leaf area in growth substrates with fallow soil. Significant differences in leaf area were found between the FS100 and BP30-AP60-P10 at flowering stage of *B. semperflorens*. In the leafing stage of begonias, there were no significant differences between growth substrates containing different proportions of peat.

Table 1. Effect of growing media on photosynthesis and respiration rate (μmol CO_2 m^{-2} s^{-1}) in leaves of *Begonia semperflorens*.

Growth Substrate	Photosynthesis Rate		Respiration Rate	
	Leafing Stage	Flowering Stage	Leafing Stage	Flowering Stage
FS100	3.102c	3.206d	0.965c	1.416c
BP30-AP60-P10	5.675b	7.705c	2.089b	3.120b
BP60-AP30-P10	8.112a	9.102a	3.004a	3.612a
BP33-C33-P33	7.112b	8.425b	2.616a	3.012b

Data presented as mean. Mean values followed by the same letter are not significantly different at $P < 0.05$ (LSD).
FS100: 100% fallow soil; BP30-AP60-P10: 30% biolan peat + 60% acid peat + 10% perlite; BP60-AP30-P10: 60% biolan peat + 30% acid peat + 10% perlite; and BP33-C33-P33: 33% biolan peat + 33% leaf compost + 33% perlite.

Three previous studies may be noted for comparison: (1) Six begonia species treated with five fertilizer concentrations were cultured in plastic containers with the soilless substrate, Metro Mix 360 (The Scotts Co., Marysville, OH), consisting of Canadian sphagnum peat moss (10 to 20%), vermiculite (25 to 40%), horticultural grade perlite (5 to 15%), bark ash (0 to 10%), pine bark (25 to 45%) analyzed shoot length, leaf area, dry weight, average number of inflorescences, inflorescence size and flower number per inflorescence (Jeong et al. 2010).

(2) Salvia (*Salvia splendens*) 'Red Vista' or 'Purple Vista,' french marigold (*Tagetes patula*) 'Little Hero Orange,' bell pepper (*Capsicum annuum*) 'Better Bell,' impatiens (*Impatiens walleriana*) 'Accent White,' and wax begonia (*Begonia semperflorens-cultorum*) 'Cocktail Vodka' were grown in two different potting substrates (Broschat and Moore 2001).

(3) Number of leaves per plant, leaf area, number of flowers per plant and other growth and flowering observations of gerbera were evaluated on growing media containing garden soil mixture with sand, silt, coconut coir or spent mushroom compost. Ahmad et al. (2012) noted that the medium containing garden soil and silt produced maximum leaf area and the highest number of flowers per gerbera plant.

In our study, the BP60-AP30-P10 substrate was the most adequate for flower bud formation. Growth substrates for begonias did not show significant differences in number of flowers per plant in the leafing stage between the BP30-AP60-P10 and the BP33-C33-P33 media. *B. semperflorens* had the lowest number of flowers in growth substrates with fallow soil, while the BP60-AP30-P10, which indicated the smallest number of flowers compared to leaf area had the greatest effect.

Leaf area / flowers ratio is an important tool that can characterize the ornamental value and the flowering potential according to the foliar surface of the plant. Analyzing the leaf area / flowers ratio in this study, we observed significant differences between the FS100 and BP33-C33-P33 media. Begonia plants registered the highest value of leaf area / flowers ratio in the BP33-C33-P33 growing medium. Growth substrates of 30% or 60% peat percentage did not show significant differences (Table 4).

Begonia semperflorens cultorum Hort. 'Ambassador Scarlet' grown in three soilless media, Metro-Mix220, Metro-Mix 366Coir, and Metro-Mix 500, had varying ratios of peat moss, coconut coir, perlite, vermiculite, and pine bark. These results confirmed the findings of James and van Iersel (2001) who observed that begonias grown in Metro-Mix 220 had significantly more inflorescences than those grown in Metro-Mix 366Coir.

Ribeiro et al. (2000) found that around 10 to 20% municipal solid wastes mixed with peat for preparation of growing media promoted the highest plant growth for potted geraniums. Hemández-Apaolaza et al. (2005) reported that *Cupressus arizonica* and *Cupressus sempervirens* were grown well in a substrate containing pine bark or coconut fiber and 30% of biosolid compost. According to the reference published by Grigatti et al. (2007), the medium with peat and 25% green waste compost produced the highest number of flowers in *B. semperflorens* cv. Bellavista F1. This is in agreement with our results and confirms the notion that *B. semperflorens* could be developed as horticultural growing media.

These findings suggest that BP60-AP30-P10 media could be used to improve plant quality of *B. semperflorens*. The growth substrates used in this study influenced physiological parameters, leafing and flowering

Table 2. Effect of growing media on chlorophyll a, chlorophyll b and Chl a / Chl b ratio in leaves of *Begonia semperflorens*.

Growth Substrate	Chlorophyll a		Chlorophyll b		Chl a / Chl b Ratio	
	Leafing Stage	Flowering Stage	Leafing Stage	Flowering Stage	Leafing Stage	Flowering Stage
	mg g^{-1}					
FS100	5.688c	6.013b	2.105b	2.225c	2.702a	2.742c
BP30-AP60-P10	7.115b	10.001a	3.001a	3.128b	2.370b	3.197b
BP60-AP30-P10	9.256a	11.412a	3.206a	3.216b	2.887a	3.548a
BP33-C33-P33	8.661a	10.412a	3.169a	3.445a	2.733a	3.022b

Data presented as mean. Mean values followed by the same letter are not significantly different at $P < 0.05$ (LSD).
FS100: 100% fallow soil; BP30-AP60-P10: 30% biolan peat + 60% acid peat + 10% perlite; BP60-AP30-P10: 60% biolan peat + 30% acid peat + 10% perlite; and BP33-C33-P33: 33% biolan peat + 33% leaf compost + 33% perlite.

Table 3. Effect of growing media on total leaf chlorophyll content, carotenoids (Car), and Chl a+b / Car ratio in leaves of *Begonia semperflorens*.

Growth Substrate	Total Leaf Chlorophyll Content		Carotenoids		Chl a+b / Car Ratio	
	Leafing Stage	Flowering Stage	Leafing Stage	Flowering Stage	Leafing Stage	Flowering Stage
	mg g^{-1}					
FS100	7.793c	8.238a	0.825c	0.997c	9.446b	8.262b
BP30-AP60-P10	10.321b	13.129b	1.018b	1.412b	10.138b	9.298a
BP60-AP30-P10	12.462a	14.628a	1.109a	2.006a	11.237a	7.292c
BP33-C33-P33	11.830a	13.857b	1.002b	1.663b	11.806a	8.332b

Data presented as mean. Mean values followed by the same letter are not significantly different at $P < 0.05$ (LSD).
FS100: 100% fallow soil; BP30-AP60-P10: 30% biolan peat + 60% acid peat + 10% perlite; BP60-AP30-P10: 60% biolan peat + 30% acid peat + 10% perlite; and BP33-C33-P33: 33% biolan peat + 33% leaf compost + 33% perlite.

Table 4. Effect of growing media on number of leaves per plant, leaf area, number of flowers/plant, and leaf area/ flowers ratio in *Begonia semperflorens*.

Growth Substrate	Number of Leaves per Plant		Leaf Area dm^2		Number of Flowers / Plant	Leaf Area / Flowers Ratio
	Leafing Stage	Flowering Stage	Leafing Stage	Flowering Stage		
FS100	8b	12c	0.138b	0.261c	2a	0.130b
BP30-AP60-P10	11a	22b	0.452a	1.012b	9b	0.112c
BP60-AP30-P10	12a	31a	0.551a	1.453a	14c	0.103c
BP33-C33-P33	11a	14c	0.464a	0.944b	5b	0.188a

Data presented as mean. Mean values followed by the same letter are not significantly different at $P < 0.05$ (LSD).
FS100: 100% fallow soil; BP30-AP60-P10: 30% biolan peat + 60% acid peat + 10% perlite; BP60-AP30-P10: 60% biolan peat + 30% acid peat + 10% perlite; and BP33-C33-P33: 33% biolan peat + 33% leaf compost + 33% perlite.

phenological stages, flowering precocity and ornamental value. This investigation showed positive correlation between the number of flowers and the leaf area. The parameters studied were significantly influenced by the type of growing components and the proportion in the mixture. Begonia plants grown in media with 60% biolan peat, 30% acid peat and 10% perlite seem to be high-value ornamental plants, while the ornamental value of the plants cultured in media containing fallow soil (FS100) is too low.

REFERENCES CITED

AHMAD I, AHMAD T, GULFAM A, SALEEM M. 2012. Growth and flowering of gerbera as influenced by various horticultural substrates. Pakistan J Bot 44: 291–299.

BENITO M, MASAGUER A, DE ANTONIO R, MOLINER A. 2005. Use of pruning waste compost as a component in soilless growing media. Bioresource Technol 96(5): 597–603.

BOROWSKI E, NURZYNSKI J. 2012. Effect of different growing substrates on the photosynthesis parameters and fruit yield of greenhouse-grown tomato. Acta Sci Pol Hortorum Cultus 11(6): 95–105.

BROSCHAT TK, MOORE KA. 2001. Influence of substrate and fertilizer analysis and rate on growth and quality of five species of bedding plants. HortTechnology 11(3): 434–437.

CARMONA E, MORENO MT, AVILÉS M, ORDOVAS J. 2012. Composting of wine industry wastes and their use as a substrate for growing soilless ornamental plants. Span J Agric Res 10(2): 482–491.

CHEN J, MCCONNELL DB, ROBINSON CA, CALDWELL RD, HUANG Y. 2002. Production and interior performances of tropical ornamental foliage plants grown in container substrates amended with compost. Compost Sci Util 10(3): 217–225.

DE LUCIA B, VECCHIETTI L, RINALDI S, RIVERA CM, TRINCHERA A, REA E. 2013. Effect of peat-reduced and peat-free substrates on rosemary growth. J Plant Nutr 36: 863–876.

FASCELLA G, ZIZZO GV. 2005. Effect of growing media on yield and quality of soilless cultivated rose. Acta Hort 697: 133–138.

GARCÍA-GÓMEZ A, BERNAL MP, ROIG A. 2002. Growth of ornamental plants in two composts prepared from agroindustrial wastes. Bioresour Technol 83: 81–87.

GRIGATTI M, GIORGIONI ME, CIAVATTA C. 2007. Compost-based growing media: Influence on growth and nutrient use of bedding plants. Bioresour Technol 98: 3526–3534.

HARGREAVES JC, ADL MS, WARMAN PR. 2008. A review of the use of composted municipal solid waste in agriculture. Agric Ecosyst Environ 123: 1–14.

HEMÁNDEZ-APAOLAZA L, GASCÓ AM, GASCÓ JM, GUERRERO F. 2005. Reuse of waste materials as growing medium for ornamental plants. Bioresour Technol 96: 125–131.

HICKLENTON PR, RODD V, WARMAN PR. 2001. The effectiveness and consistency of source-separated municipal solid waste and bark composts as components of container growing media. Sci Hortic-Amsterdam 91: 365–378.

HOLM G. 1954. Chlorophyll mutations in barley. Acta Agric Scand 4: 457–471.

JAMES E, van IERSEL M. 2001. Ebb and flow production of petunias and begonias as affected by fertilizers with different phosphorus content. HortScience 36(2): 282–285.

JEONG KY, PASIAN CC, MCMAHON M, TAY D. 2010. Response of six begonia species to fertilizer concentration and substrate pH. Open Horticulture Journal 3: 36–46.

LARCHER F, BERRUTI A, GULLINO P, SCARIOT V. 2011. Reducing peat and growth regulator input in camellia pot cultivation. HortScience 38: 35–42.

MOCCALDI LA, RUNKLE ES. 2007. Modeling the effects of temperature and photosynthetic daily light integral on growth and flowering of *Salvia splendens* and *Tagetes patula*. J Am Soc Hortic Sci 132(3): 283–288.

MORALES-CORTS MR, GOMEZ-SANCHEZ M, PEREZ-SANCHEZ R. 2014. Evaluation of green/pruning wastes compost and vermicompost, slumgum compost and their mixes as growing media for horticultural production. Sci Hortic-Amsterdam 172: 155–160.

NEMALI KS, van IERSEL MW. 2004. Light effects on wax begonia: photosynthesis, growth respiration, maintenance respiration, and carbon use efficiency. J Am Soc Hortic Sci 129(3): 416–424.

OH W, CHEON IH, KIM KS, RUNKLE ES. 2009. Photosynthetic daily light integral influences flowering time and crop characteristics of *Cyclamen persicum*. HortScience 44(2): 341–344.

RIBEIRO HM, VASCONCELOS E, DOS SANTOS JQ. 2000. Fertilisation of potted geranium with a municipal solid waste compost. Bioresour Technol 73: 247–249.

RINALDI S, DE LUCIA B, SALVATI L, REA E. 2014. Understanding complexity in the response of ornamental rosemary to different substrates: A multivariate analysis. SciHortic-Amsterdam 176: 218–224.

STULTS DZ, AXSMITH BJ. 2011. First macrofossil record of Begonia (Begoniaceae). Am J Bot 98(1): 150–153.

ZHANG KM, YU HJ, SHI K, ZHOU YH, YU JQ, XIA XJ. 2010. Photoprotective roles of anthocyanins in *Begonia semperflorens*. Plant Sci 179(3): 202–208.