ROGÉRIO GOMES PÊGO

# GROWING AND FLOWERING CONTROL OF CAMPANULA POTTED AND POSTHARVEST OF CUT FLOWERS (*Campanula medium* L.)

Tese apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduação em Fitotecnia, para obtenção do título de *Doctor Scientiae*.

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APROVADA: 12 de novembro de 2013.

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(Co-orientador)

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**Dedico,**

Aos meus pais, Darley (Seu Lico) e Maria Judith (Dona Dita),

Aos meus irmãos (Ademir, Jalmir, Luciano e Vinícius),

Às minhas (Eliana e Suely).

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E a todos os meus amigos.

# BIOGRAFIA

Rogério Gomes Pêgo, filho de Darley Gomes Paiva e Maria Judith Gomes Pêgo nasceu em Capelinha, Minas Gerais, em 18 de agosto de 1983. Cursou o ensino fundamental e médio na Escola Estadual Augusto Barbosa no município de Angelândia-MG.

Em 2003, iniciou o curso de Agronomia da Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM), onde foi bolsista de iniciação científica desenvolvendo trabalhos na área de produção e tecnologia de sementes olerícolas e espécies nativas com potencial ornamental, além de trabalhos relacionados à nutrição mineral de plantas.

Em janeiro de 2008 graduou-se em Agronomia e em fevereiro desse mesmo ano, iniciou o curso de mestrado em Agronomia - Fisiologia Vegetal pela Universidade Federal de Lavras (UFLA), sob a orientação da Prof. Dra. Patrícia Duarte de Oliveira Paiva, desenvolvendo trabalhos relacionados à micropropagação de plantas ornamentais, concluindo-o em julho de 2009.

Em Julho de 2009 iniciou o curso de doutorado em Fitotecnia pela Universidade Federal de Viçosa, sendo bolsista do CNPq. Trabalhou com propagação sexuada e assexuada de plantas ornamentais tendo como foco da tese de doutorado o controle do crescimento, florescimento e pós-colheita de campânulas. Defendendo o doutorado em novembro de 2013.

**SUMÁRIO**

# RESUMO

PÊGO, Rogério Gomes, DSc., Universidade Federal de Viçosa, Novembro de 2013. **Controle do crescimento e florescimento de campânulas envasadas e pós-colheita de flores de corte (*Campanula medium*)**. Orientador: José Antonio Saraiva Grossi. Co-orientadores: José Geraldo Barbosa e Sebastião Martins Filho.

*Campanula medium* é uma espécie ornamental de dia longo (LD) que necessita da técnica de noite interrompida para indução ao florescimento; para ajustar da arquitetura de plantas envasadas, frequentemente são usados retardantes de crescimento. Quando comercializadas como flor de corte, é necessário compreender a dinâmica pós-colheita de hastes florais. Devido ao pouco conhecimento técnico sobre a produção de campanulas, essa pesquisa objetivou elucidar algumas das principais técnicas de produção dessas flores, para isso os seguintes experimentos foram avaliados: 1) esse estudo objetivou estabelecer a melhor fonte luminosa para indução floral e produção de plantas de campanulas de qualidade. Para isso, *C. medium* 'Champion Pink' e 'Champion Blue' foram cultivadas sob dias curtos (SD), 8 horas de fotoperíodo, durante as primeiras oito semanas. Em seguida as plantas foram induzidas ao florescimento pela exposição ao LD, 16 horas de fotoperíodo, pela interrupção da noite por iluminação contínua durante 22:00-02:00 horas usando iluminação artificial durante três semanas. A iluminação foi fornecida por lâmpadas incandescentes de 100W, fluorescentes de 23W, lâmpadas de alta pressão de sódio (HPS) de 70W e LED 3W, sendo o controle mantido sob dia curto (não iluminadas). 2) O objetivo foi determinar o retardante de crescimento mais adequado para o cultivo de plantas de campanulas ‘Champion Pink’, ‘Champion Blue’ e ‘Champion White’. Após a indução floral, um lote de plantas das variedades ‘Champion Pink’, ‘Champion Blue’ e ‘Champion White’ foram pulverizadas com soluções de Daminozide nas concentrações de 1000, 2000, 3000 e 4000 mg $L^{-1}$. No segundo experimento as plantas foram tratadas foram tratadas com as concentrações de 10, 20, 30 e 40 mg $L^{-1}$ de paclobutrazol, sendo a aplicação pela irrigação do substrato. As plantas controle foram tratadas com água destilada. 3) O objetivo foi determinar a melhor concentração de sacarose na solução de pulsing para conservação pós-colheita de hastes de campânula ‘Champion White’. As hastes florais de campânula foram padronizadas com 60 cm de comprimento e 15 a 20 flores abertas por hastes e em seguida e tratadas individualmente por 24 horas em solução de sacarose nas concentrações de 0 %, 1 %, 3% e 5%. As hastes florais foram transferidas para vasos

contendo 200 ml de água e mantidas até o final da vida do vaso. 4) O objetivo desse estudo foi relatar a primeira ocorrência de *Sclerotinia sclerotiorum*, causando perda de qualidade ornamental em *Campanula medium*. Para isso foi observada a ocorrência e desenvolvimento da doença em cada uma das variedades e a identificação do patógeno foi realizada por meio de testes laboratoriais. Os resultados mostram que a interrupção da noite é necessária para a indução floral de campânulas 'Champion Pink' e 'Champion Blue'. Para indução floral de 'Champion Pink' e 'Champion Blue' pode-se usar lâmpadas incandescentes, fluorescentes, de sódio de alta pressão ou LED. É possível a produção de 'Champion Pink' e ‘Champion Blue’ em vaso de alto valor ornamental que atendam ao mercado. As concentrações de 40 mg $L^{-1}$ de paclobutrazol ou 4000 mg $L^{-1}$ de Daminozide podem ser usadas para controle do crescimento de campânulas de vaso ‘Champion Pink’ e ‘Champion Blue’ e 'Champion White'. Há redução da produção de massa seca de caule, flores e folhas, número de flores e área foliar. As concentrações estudadas não afetam a qualidade ornamental de campânula em vaso, mas aumentam o período de produção. Maior absorção de água foi observada nas hastes tratadas com 5 % de sacarose. Houve perda de peso das hastes após as primeiras 24 horas do tratamento de pulsing, no entanto, em concentrações de 1% a 3 % os pesos dos caules foram constantes até ao final da vida de vaso. As hastes florais tratadas com 1% de sacarose mantiveram o índice SPAD, que mede a coloração verde das folhas, por longo período, quando comparado com os outros tratamentos. A maior longevidade de 6,8 dias foi observada nas hastes florais tratadas com 1,0%, e a menor, de 3,6 dias, foi obtida em hastes tratadas com 5% de sacarose na solução pulsing. Foi observada a ocorrência de *Sclerotinia sclerotiorum* causando perda de qualidade ornamental em plantas de campânulas 'Champion Pink' ‘Champion Blue' e 'Champion White’ em 20 %, 22% e 7%, respectivamente. A infecção por *S. sclerotiorum* foi iniciada nas bordas das folhas desenvolvendo ao longo da folha, predominantemente ao longo dos feixes vasculares. O dano mais grave ocorreu após a infecção da haste floral pelos fungos causando anelamento e crescimento de micélios cotonosos. Posteriormente, observou-se a murcha, tombamento e perda da qualidade ornamental das plantas. A presença de escleródios, estruturas de resistência típica da doença, foi também observada.

## ABSTRACT

PÊGO, Rogério Gomes, D.Sc., Universidade Federal de Viçosa, November 2013. **Growing and flowering control of campanula potted and postharvest of cut flowers (*Campanula medium* L.)**. Adviser: José Antonio Saraiva Grossi. Co-adivisers: José Geraldo Barbosa and Sebastião Martins Filho.

*Campanula medium* is an ornamental kind of long day (LD) who needs of night interrupted technique to forcing; to adjust the architecture of potted plants growth retardants are often used. When commercialized as a cut flower, it is necessary to understand the dynamics of postharvest cut flowers. Thus, this study aimed to elucidate some of main techniques to flowers production, for this the following experiments were evaluated: 1) This study aimed to establish the best light source for floral induction and plant production campanulas quality. For this *C. medium* 'Champion Pink' and 'Champion Blue' were grown under short days (SD), 8 hour photoperiod, during the first eight weeks. Then the plants were induced to flowering by exposure to LD 16 hour photoperiod, by interrupting the continuous lighting at night by 10:00 p.m. to 2:00 a.m. by using artificial light for three weeks. The lighting was provided by incandescent 100W, 23W fluorescent lamps, 70W high pressure sodium ( HPS ) and 3W LED , control plants was kept under short day (not light). 2) The objective was to determine a growth retardant for growing plants campanulas 'Champion Pink ', 'Champion Blue' and 'Champion White' in greenery and illuminated with 100W incandescent lamp. After floral induction, a group all varieties plants 'Champion Pink' , 'Champion Blue ', and 'Champion White' were sprayed with solutions at concentrations of Daminozide 1000, 2000, 3000 and 4000 mg $L^{-1}$. The second group of plants was treated with paclobutrazol concentrations of 10, 20, 30 and 40 mg $L^{-1}$. The control plants of both experiments were treated with distilled water. 3) The objective was to determine the best concentration of sucrose in pulsing solution for post-harvest preservation of stem flowers of 'Champion White'. The Campanula stem flower were standardized to 60 cm in length with 15 to 20 open flowers and kept individually for 24 hours in a sucrose solution at 0%, 1%, 3% and 5% concentrations. The stem flowers were transferred to individual pots containing 200 ml of water and kept until the end of vase life. 4) The objective of this study was to report the first occurrence of *Sclerotinia sclerotiorum*, causing loss of quality ornamental *C. medium*. To it was observed the occurrence and development of

disease in each of varieties and identification of pathogen was performed using laboratory tests. The results showed that the interruption of the night is required for floral induction of cowls ' Champion Pink' and ' Champion Blue'. For induction of floral 'Champion Pink' and 'Champion Blue' can use incandescent, fluorescent, high pressure sodium or LED. It is possible to produce 'Champion Pink' and 'Champion Blue' potted high ornamental value that meets the market. The concentration of 40 mg $L^{-1}$ paclobutrazol or 4000 mg $L^{-1}$ Daminozide can be used to growth control of 'Champion Pink' and 'Blue Champion" and "Champion White'. It reduces the production of stem dry mass, flowers and leaves, number of flowers and leaf area. The concentrations studied did not affect the quality of ornamental potted campanula, but increased the production period. The higher water absorption was observed in the treated stems with 5% sucrose. There was a loss of weight of stem after the first 24 hours of treatment pulsing, however, in concentrations from 1% to 3% the weight of stems were constant until the end of life vase. The stem flower treated with 1 % sucrose maintained SPAD index, which measures the green coloring of the leaves for a long period when compared with other treatments. The longevity of 6.8 days was observed in stem flower treated with 1.0 % and shorter of 3.6 days longevity was obtained in stems treated with 5% sucrose solution in pulsing. Was observed the occurrence of *Sclerotinia sclerotiorum* causing loss of quality ornamental campanula 'Champion Pink' 'Blue Champion’ and ‘White Champion' 20% , 22% and 7% of cultivated plants , respectively. Infection with *S. sclerotiorum* was initiated at the edges of leaf and developed predominantly along the vascular veins. The most severe damage occurred after of fungi infect the stem causing girdling and evolving for the growth of mycelia as cotton aspect. Subsequently, it was observed wilt, loss of quality ornamental plants and damping off. The presence of sclerotia, a resistance structures typical characteristic of the disease, was also observed.

## 1. INTRODUCTION

Brazilian floriculture has grown each year and demands to high-quality products are required by consumers. The search for differentiated products as new species or hybrid of cut flowers and potted flowers, enable, along with traditional products promote this productive sector.

*Campanula medium*, commonly known as campanula, Canterbury bells or bellflowers, is a recently introduced species in the Brazilian market of flowers. Although these plants are primarily commercialized as potted plants in Brazilian market, in European countries or in United States of America, they are mainly cultivated as cut plants or flowering plants in ornamental gardens.

The Atibaia region in São Paulo state is the largest producer of campanulas in Brazil. However, information on photoperiodic control, use of growth retardants and post-harvest are yet demanded by farmers. Thus, this thesis provides important information for the management and production of these plants.

Campanulas are long-day plants and need of photoperiodic control to flowering. Traditionally, incandescent lamps have been used to photoperiodic control, but progress in technology enables the use of alternative devices for the production of flowers. Therefore, were tested lighting alternative for producers of campanula using news sources of light. Another cropping technique cultivation few reported is the use of growth retardants, although some recommendations and uses of theses retardants, no studies of doses for growing campanulas were studied. Due to the potential for use as a cut flower, it is necessary to conduct experiments that enable better handling after harvesting to extend the vase life.

Thus, this thesis presents important steps to cultivate campanulas, to improve production technologies and consequently contribute to the market of ornamental plants.

## 2. LITERATURE

The floriculture agribusiness has been a good option to improve income for farmers. In 2012, the Brazilian market exported a value of R$ 59.25 million in products as flowers and ornamental plants (Junqueira and Peetz, 2013).

The competitive market has demanded numerous researches to produce hybrids, methodologies to break dormancy seeds, adequate environments cultivate or improvements in lighting systems for photoperiod control in floriculture; beyond supplemental light for growing plants in countries where natural light deficiency occurs has been an obstacle for production of flowers.

Recently a new group of plants in the family Campanulaceae was introduced in Brazilian market with high decorative value and its marketing is booming (Gioria et al., 2010). Those plants have already been established in European countries market and in the United States as ornamentals cutting or potted plant (Serek, 1991).

The genus Campanula includes about 400-600 species and naturally occurs almost exclusively in temperate zone of hemisphere, for example, in Mediterranean region, the Caucasus and the European Alps (Kuss et al., 2007). The plants are popularly known as campanula, bellflower or Canterbury bell, due to shape of flowers. In Japan these flowers are used as symbol of gratitude, which has been used to marketing also in Brazil.

In Europe, United States and Japan, the species commonly commercialized as cut flowers are *Campanula medium*, *C. carpatica*, *C. isophylla*, *C. glomerata*, and *C. persicifolia*, but *C. medium* is also cultivated as potted plant (Serek, 1991, Torre and Moe, 1998; Latimer et al. 2001, Bosma and Dole, 2002). However, cultivar *C. medium* ‘Champion’ has been commonly cultivated due to versatility of using and to be easily cultivated (Dole et al. 2001).

The varieties ‘Champion Blue’, ‘Champion Pink’, ‘Champion Lavender’ and ‘Champion White’ of *C. medium,* has been commercialized by Sakata Seed Sudamerica Ltd Company as seed or seedless. According Bosma and Dole (2002) the inflorescence of *C. medium* is a raceme of 2.5 cm long, cup shaped flowers creating an unusual shape not common cut flowers; the floral stem of up to 75 cm long arise from pubescent plant and biennial plant.

The Atibaia region in São Paulo state is the largest producer of campanula of Brazil and their marketing is done mainly via Veiling Holambra cooperative or central supply as CEASA Campinas. In September 2013, the potted plant was marked to R$ 7.40 each, but there is no marketing campanulas cut flower in Brazil; however there is potential use for this purpose (Bosma and Dole, 2002; Veiling Holambra, 2013).

In commercial production of campanulas new interests and demands for improved cultivars which exhibit compact and uniform growth, has been expected, as for example, new F1 hybrids, as occur whit *C. medium* (Dole, 2005).

Many species require special conditions to production. The propagation by seed germination under 18°C to 20°C is more commonly used, but vegetative cuttings or divisions plants also are used (Dole et al., 2001). Many species of campanula are long-day plants and need of photoperiodic control to flowering. The vegetative stage depends of specie or variety and can during 20 and 27 week long in *C. carpatica* 'Dark Blue' and 'Karl Foerster' (Andersen and Hansen et al., 2002; Serek, 1991), but *C. medium* can be cultivated from 8-9 leaf stage under 8 hours short-day during 8 week (Cavins and Dole, 2001). To forcing campanulas need of 14 to 16 hours long day to flowering as showed on cultivate of *C. carpatica* and *C. medium* (Serek, 1991; Cavins and Dole, 2001).

The flowering of long day plants is controlled by interruption of night period regulated by phytochrome. The phytochrome is a protein that absorbs light in the range of red and far-red visible spectrum corresponding to wavelengths between 660-730 nanometers (nm), respectively (Marrow, 2008). The phytochrome red (inactive form), to absorb red light (660 nm), is rapidly converted to the form of phytochrome far-red (active form); while the phytochrome far-red by absorbing far-red light (730 nm), is converted to the red form of phytochrome (Barbosa et al, 2005). This conversion also occurs in the dark, though more slowly. On market there are many dispositive light emitting; the predominant characteristic of wavelengths depends of the use of each one.

Traditionally incandescent lamps have been used to flowering control, but they are inefficient to convert light energy; for this new dispositive has been developed to floriculture application (Runkle et al., 2012). Fluorescent lamps have potential to replace incandescent lamps and reduce energy consumption to flowering control

(Barbosa, et al., 2005); often this lighting source is used to growing control in countries when the irradiation is insufficient to growing of plants as into growing room on *in vitro* propagation.

High pressure sodium lamps are used to light supplementation in greenhouse to promote growing or flowering control (Blankenship and Dole, 2003). These lamps are one of most common sources to light supplementation to horticulture in countries where additional lighting is required to obtain quality products, but it is also used to control photoperiod (Tazawa, 1999).

The light emitting diode (LED) is the new light dispositive that has required much research to application in horticulture. The great advantage of this dispositive is the possibility the selection of wavelength of spectrum of visible light to emit a specific wavelengths and the economy of energy compared to other sources (Morrow, 2008). It was estimated that the use of 2 W LED presented economy of 96.5% of electricity compared to 100W incandescent light in chrysanthemum flowering control, without loss of quality (Zanotelli, 2009).

The incandescent light bulbs have above 50% relative intensity at wavelength 630 nm, while the present fluorescent lamps emission peak around 430 nm and 570 nm and the HPS lamp has spectral characteristic peaks at 589 and 595 nm (Tazawa, 1999). According Zanotelli (2009), the LEDs are dispositive with potential use in agriculture because is possible select the visible wavelength region according to interest of manufacturer.

It was observed that the photoperiodic requirement for flowering campanula species is variable. Under long days, provided by incandescent lamps, *C. garganica* and *C. glomerata* flowered completely and faster, and *C. garganica* also had more buds (Padhye et al., 2005). *C. carpatica* and *C. punctata* plants under short days grown forming rosettes and produce no flowers; but when grown under long days, plants elongate and produces numerous flowers. The critical photoperiod of *C. carpatica* ‘Blue Clips’ is 14 hours. It should be noted that ‘Blue Clips’ flowers faster under photoperiods of 16 or more hours compared to 14 hours using incandescent lamps (Dole, 2005; Padhye et al., 2005).

*C. carpatica* ‘Pearl Deep Blue’ grown under the 9-h photoperiod were vegetative after 16 weeks, indicating that this species is LD plants; when grown under SDs, all plants remained as a rosette. These authors observed no significant difference between continuous or intermittent lighting, but the combining incandescent lamps and HPS lamps the plants improved the number of flowers and the time to flowers was lower (Blanchard and Runkle, 2010).

In campanula ‘Pearl Deep Blue’ cultivated under incandescent or fluorescent lamps, the lighting type had no effect on LD lighting responses. Similarly, lamp type did not influence flowering time of campanula ‘Blue Clips’ and coreopsis ‘Early Sunrise’ when under SD 9-h and transferred to 15-h of LD light provided by INC, fluorescent, HPS, or metal halide lamps (Whitman et al., 1998; Blanchard and Runkle et al.; 2010).

The floral induction by breaking night promotes the development of floral stem of campanulas, especially in *C. medium*; thus, these flowers can reach up to 75 cm in length, which can impede the commercialization as potted plant. Therefore, often the use of growth retardants is required. A height is important to classification campanula potted plants, but outers characteristics are also important, according Veiling Holambra (2013) (Table 1).

The proportion between the pot and the plant is one of requirements for classification of the potted plant; so it is necessary to use techniques that enable the standardization to market (Barbosa et al., 2005).

One of ways to regulate the architecture of ornamental plants is the use of growth retardant. The plant growth retardants are synthetic compounds used to manipulate plant growth without decreasing productivity whose commercial products commonly used for this purpose are cycocel, paclobutrazol and daminozide which act by inhibiting the synthesis of gibberellin (Carvalho, 2010).

Table 1. Characteristics analyzed to classification of campanulas potted (Veiling Holambra, 2013)

| HEIGHT OF PLANT | | |
|---|---|---|
| **Classification** | **Minimum height** | **Maximum Height** |
| I | 25 | 35 |
| II | 36 | 45 |
| III | 46 | 60 |
| **FORM OF POTTED PLANT** | | |
| Form I | Pyramidal form | |
| Form II | Compact form | |
| **DEFECTS** | | |
| **Serious defects** | **A1** | **A2** |
| Disease (botrytis) | 0 | 0 |
| Disease (Mites, trips and caterpillars) | 0 | 03 |
| Mechanical damage on flower | Subtle intensity without compromising the beauty of the flower | |
| **Small defects** | **A1** | **A2** |
| Burns for phytotoxicity | Subtle intensity | Medium and high intensity |
| Chemical residues | Subtle intensity without compromising the beauty of the flower | |
| Nutritional deficiency, yellow dried | Subtle intensity | Medium and high intensity |

There is no study on adjustment of product and concentration most effective to regulate the size of potted plants. Serek (1991) used a dose of 50 mg $L^{-1}$ of paclobutrazol in spraying of plants to cultivate of *C. carpatica* 'Karl Foerster' at beginning of flowering, but no dose studies. This study is important because enables to establish the lowest dose that produces the desired results avoiding excessive inputs in the production of flowers. Pilon (2007) showed growth regulators B-nine (daminozide) Sumagic (uniconazole) and Bonzi (paclobutrazol) at concentrations of 2500, 5 and 30 ppm, respectively, for the production of *C. glomerata*, but also described no effect on long in height. Latimer et al. (2001) recommended cultivating of *C. persicifolia* 30 ppm Bonzi and doses less than 5000 ppm of B-nine. However, there is no correlation between the growth retardants used or concentrations indicated with the length in height of campanula. It was reported no retardant or dose to control the growth of *C. medium*.

In addition to management to growing and flowering control of campanulas, other important aspects are losses which occur during post-production or postharvest of cut flowers, which leads to loss of quality and reduces the vase life of these plants (Bosma and Dole, 2002; Sriskandarajah et al. 2007).

The extending of life postharvest can be achieved by applying treatments that reduce the rate of senescence and increase the water content of stem cut flowers; an effective postharvest treatment consists to applying preservative solutions as pulsing, where the stems are placed in a solution containing one or more substances, for 24 to 48 hours immediately after harvesting or after cold storing (Alves, 2012).

Almeida et al. (2011) reported that sucrose can affect the flower opening after harvesting and the tissue turgidity of stem and flowers. These authors reported that sucrose supply by pulsing is an energy source also its presence decreases the water potential of the inflorescence which improves water uptake by the flower stalk and can be used 5 to 7.5% to preserve calla lily inflorescences.

Sucrose is an important determinant of cut flowers because of its ease of using, low cost and accessibility. Dole and Wilkins (2005) reported campanula cut flowers can be stored at 2 to 6°C in solution or dry during one week. Bosma and Dole (2002) reported pulsing solution using water at room temperature and 5% sucrose diluted have no effect on extension on vase life in *C. medium* 'Champion Pink' but the pulsing with water at 38°C extended the life vase in 7.3 to 10.3 days. These authors reported combining sucrose with other preventive compounds, the extending of postharvest life can be possible.

For the production of ornamental plants of high quality is necessary that all factors of production are efficiently controlled. In addition to factors previously cited, the efficient management during each step of production, harvest and post-harvest should be considered as a disease control. According to standards of Veiling Holambra, the damage caused by microorganisms is one of observed characteristics that limit the commercialization of plant campanula (Veiling Holambra, 2013).

There is few information on occurrence of diseases and damage causing loss in campanula plants but were identified Tomato spotted wilt virus (TSWV) on *C. medium* grown in the Atibaia region (Gioria et al., 2010). In Italy, were also identified on campanula plants pathogens as *S. sclerotiorum* on *C. carpatica*, *Phoma sp.* on *C. lactiflora* and powdery caused by *Golovinomyces orontii* on *C. rapunculoides* (Garibaldi et al., 2002; Garibaldi et al., 2010, Garibaldi et al. 2012). Therefore the identification of pathogens and damage level on campanulas should be studied to avoiding loss during production and postharvest plant and, thus, obtain high quality flowers for the Brazilian market.

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## ARTIGO 1

# LIGHT SOURCES TO FORCING FLOWERING AND QUALITY OF *Campanula medium* 'CHAMPION PINK' AND 'CHAMPION BLUE' POTTED PLANTS

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**LIGHT SOURCES TO FORCING FLOWERING AND QUALITY OF *Campanula medium* 'CHAMPION PINK' AND 'CHAMPION BLUE' POTTED PLANTS**


**ABSTRACT**

*Campanula medium,* an ornamental species, is a long-day (LD) plant. In the agriculture are many types of light sources, but there are few studies on their uses to production of campanulas. Therefore this study was aimed to determine the most appropriate light sources to forcing flowering and quality of *Campanula medium* 'Champion Pink' and 'Champion Blue' potted plants. The plants were grown under short-day (SD), 8 hour photoperiod, during the first eight weeks. To forcing flowering plants were transferred to LD, under 16 hour photoperiod, by broken night with continuous light from 10:00 pm to 2:00 am using artificial lighting from lamps, during three weeks. The artificial lighting was provided by 100W incandescent, 23W fluorescent, 70W high pressure sodium (HPS) and 3W LED; as a control treatment plants were maintained under short-day throughout the period of artificial lighting (without supplementary lighting). The light sources were arranged at 80 cm height from potted plants. The plant height, flower number, length and diameter of flowers, cycle (period from transplanting to the point of sale), leaf number, leaf dry mass, flower dry mass and stem dry mass were evaluate when plants reached up to 50% of the plants reached the commercial characteristics. It's necessary the interruption night to force campanulas 'Champion Pink' and 'Champion Blue'. Light sources forcing campanulas 'Champion Pink' and 'Champion Blue' can be incandescent, fluorescent, high pressure sodium or light emitting diodes (LED). Is possible the production of 'Champion Pink' and 'Champion Blue' potted of high ornamental value serving to market, so any one sources can be used.



**KEY WORDS**: Canterbury bells; bellflowers; photoperiod; flowering

**FONTES DE LUZ PARA INDUÇÃO DO FLORESCIMENTO E QUALIDADE DE *Campanula medium* 'Champion PINK' AND 'Champion BLUE' ENVASADAS**

RESUMO

*Campanula medium*, uma espécie ornamental, é uma planta ornamental de dia longo (LD). Na agricultura são usadas diferentes de fontes de luz para o controle fotoperiódico, mas existem poucos estudos sobre seus usos para produção de campânulas. Assim, esse trabalho objetivou determinar as fontes de luz mais adequadas para indução floral e qualidade de campanula de vaso 'Champion Pink' e 'Champion Blue'. As plantas foram cultivadas sob dia curto (SD), 10 horas de fotoperíodo, durante as primeiras oito semanas. Para indução floral as plantas foram transferidas para LD, sob fotoperíodo de 16 horas, pela interrupção da noite com luz contínua de 22:00 – 02:00 horas pela iluminação artificial de lâmpadas, durante três semanas. A iluminação artificial foi fornecida por incandescentes de 100W, fluorescentes de 23W , de sódio de alta pressão (HPS) e de LED 3W, as plantas controle foram mantidas sob dia curto durante todo o período de iluminação artificial. As fontes de luz foram dispostas a 80 cm de altura do vaso de plantas. A altura da planta, número de flores, comprimento e diâmetro de flores, ciclo (período de transplante até o ponto de comercialização), número de folhas, massa seca das folhas, massa seca de flores e caule foram avaliados. As avaliações foram realizadas quando 50% das plantas atingiram as características comerciais. Para indução floral de 'Champion Pink' e 'Champion Blue' é necessária a interrupção da noite. As fontes de luz para indução floral de campânulas 'Champion Pink' ou 'Champion Blue' podem ser incandescente, fluorescente, sódio de alta pressão, ou LED. É possível a produção de 'Champion Pink' e 'Champion Blue' em vaso com alto valor ornamental que serve para o mercado por isso qualquer uma das fontes podem ser usadas.

PALAVRAS-CHAVE: Canterbury bell; Flor sino; fotoperíodo; florescimento

## INTRODUCTION

*Campanula medium*, commonly known as campanula, Canterbury bells or bellflowers, is an ornamental plant grown as cut plants or potted plants. These are biennial plants commonly used in gardens in temperate region countries or as potted flowers. Campanula presents pink, blue, lavender or white flower colors that are enjoyed by shape flowers. These plants can reach more than 75 cm in length and present up to 10 flower inflorescence and cup-shaped flowers creating an unusual shape on ornamental plant not common in flowers (Bosma and Dole, 2002).

The cultivated campanula species are long-day (LD) plants. Dole and Wilkins (2005) reported that *C. carpatica*, *C. isophylla*, *C. persicifolia* and *C. poscharskyana* need of 14-16 hours LD to flowering induction, but same species require cold treatment as vernalization to forcing. The new cultivars of *C. medium* are available to flower rapidly without vernalization but are obligate LD plants with a critical photoperiod between 8 to 12 hours (Cavis and Dole, 2001).

To flowering forcing, campanula can be cultivated under 16 hours of light supplementation or by technical of broken night using artificial light from 22:00 to 02:00 using incandescent lamps (Drushal, 1997). Hammer (1992) reported that fluorescent lamps can be used as light supplementation to improve growing campanula plants, these lamps have been used in greenhouse to cultivate of ornamental plants in regions of low solar irradiation (Landis et al, 1992).

The light action on flowering induction in plants sensitive to daylight is explained by phytochromes, a family of proteins that have two forms, the red absorbing form (Pr) and the far red absorbing form (Pfr) (Barbosa et al., 2005). The Pr form, which has $\lambda_{max}$ = 660 nm, is converted to the Pfr form when it absorbs light. The Pfr form, which has $\lambda_{max}$ = 730 nm, is converted to the Pr form when it absorbs light; the Pfr form is generally considered to be the active form (Stutte, 2009).

In practice, the management of lighting in agriculture to photoperiod control and forcing plants has occurred through the use of artificial light sources. Until now, the most common sources of artificial light used in Brazilian agriculture had been the incandescent and the cool white fluorescent. However, the spectrum of light emitted by a fluorescent lamps is very different from that of an incandescent lamp, which emits more far red (FR; 700–800nm) than red (R; 600–700nm) light and has a R:FR ratio of about 0.7 (Runkle et al, 2012). More recently, a new technology using light emitting diodes (LEDs) have become of great interest in the industry due to possibility of control the spectral composition wave lengths allowing to be matched with photoreceptors plant to provide production more optimal (Morrow, 2008).

Artificial lighting on campanula plants have been used to potted plants. Serek (1991) observed increased by about 50% in improvement of decorative value *C. carpatica* due to higher number of flowers and floral area when these plants were grown with supplemental irradiation 70 $\mu mol.m^{-2}s^{-1}$ light using high pressure sodium lamps (HPS). Dinesen et al. (1997) reported light supplementation dousing 06:00 to 12:00 pm using HPS lamps in greenhouse can be used to forcing plants. The flowering forcing of *C. isophylla* Moretti 'Bla' using light from incandescent or fluorescent lamps produced stems flower of 26.5 and 20.5 cm in length and 83 and 104 buds flowers, respectively (Moe et al., 1991).

The campanula were recently introduced in Brazil for commercialization as potted plant to internal market, but there are no studies on the most adequate light sources to forcing campanula in conditions of Brazil. Therefore this study was aimed to determine the most adequate light sources to forcing flowering and quality of *Campanula medium* 'Champion Pink' and 'Champion Blue' potted plants.

## MATERIAL AND METHODS

The seedlings, in plugs, used in experiment were donated by Sakata Seed Sudamerica Ltd Company, when showed commercial characteristics to sale. These seedlings were transferred to 1.0 L polyethylene pot and grown in greenhouse of Plant Science Department of Federal University of Viçosa, Viçosa - MG. The pots were filled with Tropstrato® commercial substrate whose physical and chemical characteristics are described in Table 1.

Table 1. Humidity (H), water retention capacity (WCR), Density (D), pH in water (pH) and electrical conductivity (EC) of Tropstrato® commercial substrate used to cultivate of campanula potted.

| **H * (% p/p)** | **WRC (% p/p)** | **D (kg/m³)** | **pH** | **EC (mS/cm)** |
|---|---|---|---|---|
| 60 | 130 | 490 | 5,8(±)0,5 | 2,2(±)0,3 |

* Information of package commercial.

The plants were grown under short-day (SD), 8 hour photoperiod, during the first eight weeks; for this, plants were every day covered with opaque blackout cloth from 5:00 pm to 7:00 am, making possible any light throughout the cloth. To flowering forcing plants were transferred to LD, under 16 hours of photoperiod, by broken night by continuously lighting during 10:00 pm to 2:00 am using artificial lighting from lamps, during three weeks. The broken lighting was provided by 100W incandescent, 23W fluorescent, 70W high pressure sodium (HPS) and 3W LED; as a control treatment plants were maintained under short-day throughout the period of artificial lighting (without supplementary lighting). The light sources were arranged at 80 cm from height from potted plants. Three weeks after beginning of forcing, plants from all treatments were kept under natural photoperiod until reach the point to marketing (Veiling Holambra, 2013). The natural photoperiod was calculated by proposed by Thornthwaite & Mather (1955), with the aid of "BHnorm" program established in excel spreadsheet by Rolim et al method. (1998).

The plants were fertilized twice a week with 100 mL fertilized according with the nutrient solution as follows: 54 mg $L^{-1}$ of $NO_3$-N, 1.0 mg $L^{-1}$ of NH4-N, 3 mg $L^{-1}$ of $H_2PO_4$, 31 mg $L^{-1}$ of K, 120 mg $L^{-1}$ of Ca, 15 mg $L^{-1}$ of Mg, 45 mg $L^{-1}$ of $SO_4$, 1.0 mg $L^{-1}$ of Fe, 0.50 mg $L^{-1}$ of Mn, 0.3 mg $L^{-1}$ of Zn, 0.13 mg $L^{-1}$ of Cu, 0.30 mg $L^{-1}$ of B, 0.04 mg $L^{-1}$ of Mo, 45 mg $L^{-1}$ of Cl (Andersen and Hansen, 2002). The watering was daily provided with 100 ml of water per pot. The temperature and relative air humidity were daily registered with datalogger during all production period.

The plant height, flower number, length and diameter of flowers, cycle (period from transplanting to the point of sale), leaf number, leaf dry mass, flower dry mass and stem dry mass were evaluated when plants reached 50% of the commercial point according classification rules for campanula potted of Veiling Holambra (Veiling Holambra, 2013).

The experimental design was completely randomized in a 2x5 factorial (varieties x light sources) with 15 replicates, in each pot had a plant. Data were subjected to analysis of variance and means were compared by Tukey test at 5%.

## RESULTS AND DISCUSSION

The production cycle corresponded to 09 July to 18 August period. During this period the average temperature was from 12.5 °C to 24 °C and the relative humidity was between 96% and 59% (Figure 1).

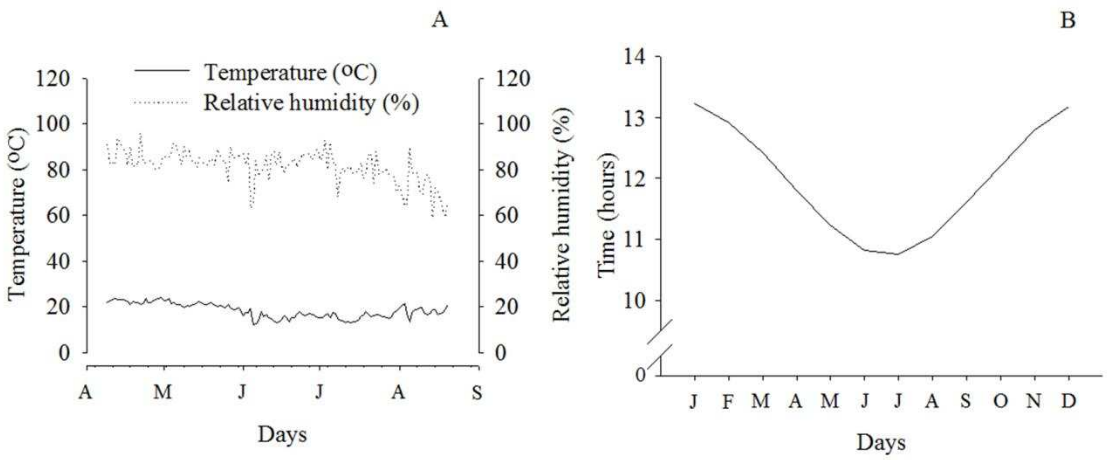


Figure 1. Average relative air humidity (%) and average temperature (°C) during production of campanula potted (A) and natural photoperiod in cultivate area in Viçosa, MG.

In first eight weeks of cultivation were observed vegetative growth of plants maintained under SD; after transferring the plants to LD condition, it was observed flowered plants, lighted independent of light sources, but no flowered plant was observed grown under SD. The campanula flowering occurred in a raceme primarily responsible for plant growth in height (Bosma and Dole, 2002). The plants exhibited vegetative growth under no light conditions showing reduced height growth in length of 17.2 and 11.0 cm, respectively to 'Champion Pink' and 'Champion Blue' varieties (Figure 2A). There was no significant difference between the different light sources for both campanula varieties that produced above 47.8 cm in height. But plants no lighted were significantly lower compared to plants grown under light sources.

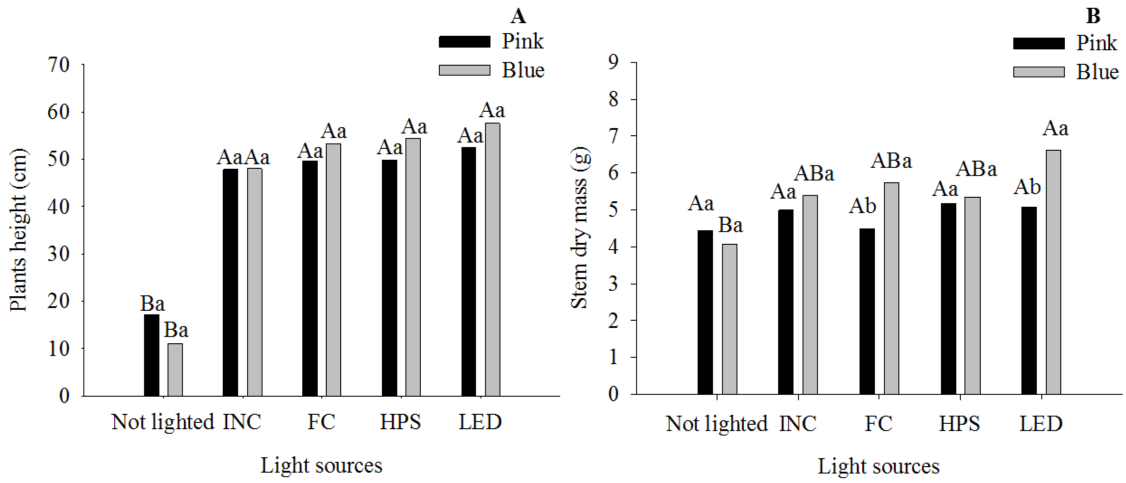


Figure 2. Plants height (cm) (A) and stem dry mass (g) of campanula 'Champion Pink' and 'Champion Blue' under light emitted by incandescent (INC), fluorescent (FC), high pressure sodium (HPS), light emitting diodes (LED) lamps or no lighted. Same upper case letter comparing lighting sources within each variety and lower case letter comparing varieties within each light source are not significantly different according to Tukey's test ($P > 0.05$).

Campanula can have height up to 75 cm in height when grown in gardens, but when they are grown in locations of naturally occurrence can range from 60 to 120 cm in length (Dole and Wilkins, 2005; Bosma and Dole, 2002). Cavins and Dole (2001) reported that campanula vegetative grown should occur under 8-h photoperiod, but to flowering 16-h photoperiod is necessary; this can be handled using incandescent lamps. In this condition the varieties 'Champion Pink' and 'Champion Blue' reached 39.2 and 43.6 cm length, respectively.

The stem dry mass of Campanula 'Champion Blue' was significantly higher in plants illuminated with LED lamps compared with not lighted plants. There was no significant difference between the light sources incandescent, fluorescent and high pressure sodium or LED on dry mass stem on 'Champion Blue' campanula (Figure 2B). The lighting using LED and fluorescent lamps improved higher accumulation stem of dry matter. Analyzing the 'Champion Blue' compared to 'Champion Pink', ground under LED light the difference of stem dry mass was 6.6 g and 5.0, respectively; to plants ground under fluorescent lamps the had stem dry mass of 5,7 and 4,5, respectively. Moe et al (1991) observed grater forcing plant development of *C. isophylla* 'Bla' stem using interrupted night by incandescent bulbs compared to fluorescent.

Campanula plants grown under short-days (no-illuminated) had more intense vegetative growing and ‘Champion Pink’ and ‘Champion Blue’ produced above 33 and 35 leaves per plant, respectively. Both varieties when were forced, produced a maximum of 20 leaves per plant, regardless of light source used, demonstrating lighting is necessary to change the vegetative to reproductive phase (Figure 3A).

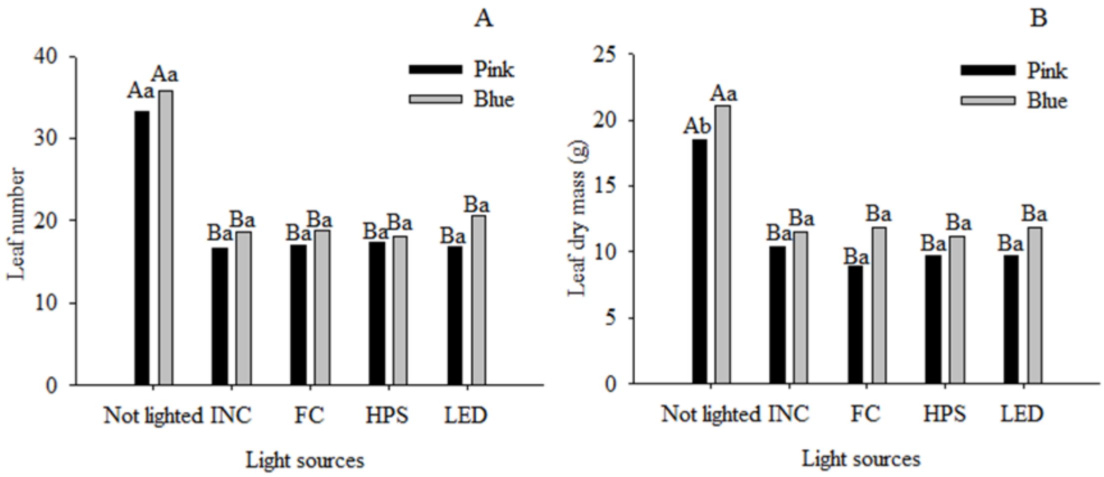


Figure 3. Leaf number (A) and leaf dry mass (g) (B) of campanula ‘Champion Pink’ and ‘Champion Blue’ under light emitted by incandescent (INC), fluorescent (FC), high pressure sodium (HPS), light emitting diodes (LED) lamps or no lighted. Same upper case letter comparing lighting sources within each variety and lower case letter comparing varieties within each light source are not significantly different according to Tukey’s test ($P > 0.05$).

The leaves dry weight was 21 g in campanula ‘Champion Blue’ plants under no light condition, compared with 18.5 g produced in campanula ‘Champion Pink’, but there was no significant difference in leaves dry weights production to both varieties regardless light source (Figure 3B). Plants under no light also produced more leaf surface area than those (Figure 4A), according with the highest number of leaves

(Figure 3A). The largest number of leaves obtained from plants that showed architecture rosette type was possible for maintenance of plants in vegetative stage and shorter lengths of internodes.

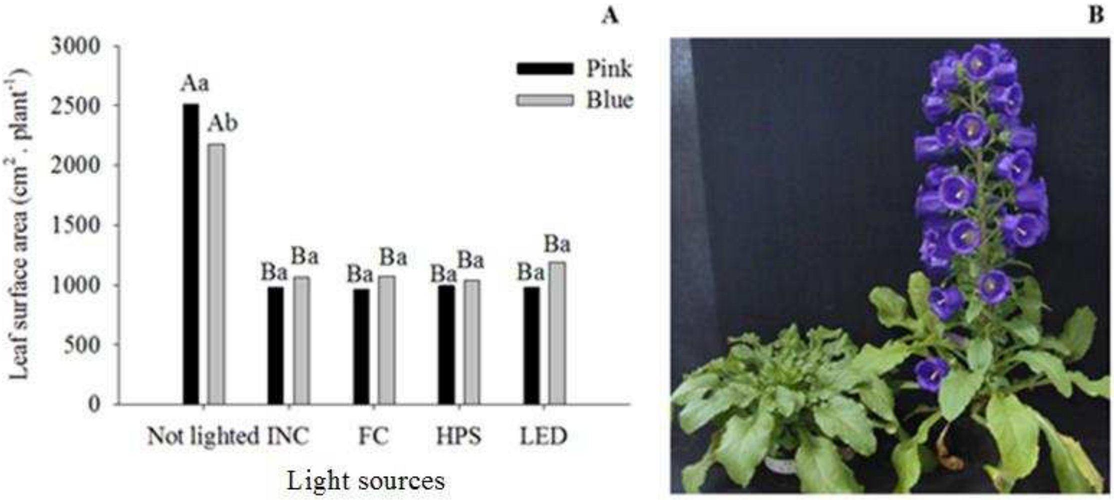


Figure 4. Leaf surface area (A) of campanula ‘Champion Pink’ and ‘Champion Blue’ under light emitted by incandescent (INC), fluorescent (FC), high pressure sodium (HPS), light emitting diodes (LED) lamps or no lighted; and view of plants grown under no lighted (left) and under LED lighting (right) (B). Same upper case letter comparing lighting sources within each variety and lower case letter comparing varieties within each light source are not significantly different according to Tukey’s test ($P > 0.05$).

There are few reports on influence of artificial lighting in number of leaves production, leaf dry mass or leaf area campanula, and research have been focused on qualitative observation on floral characteristics and quality of potted plants. Blanchard and Runkle (2010) reported that all *C. carpatica* plant grown under SD, all plants remained as a rosette, as occur with others ornamental species LD (Runkle and Heins, 2001). Petersen and Hansen (2003) reported that C. carpatica when induced to flowering with high pressure lamps sodium presented above 500 leaves and leaf area of about 1000 $cm^2$. Runkle et al. (2012) reported campanula 'Pearl Deep Blue', petunia 'Wave Purple Classic', coreopsis 'Early Sunrise' and rudbeckia 'Becky Cinnamon Bicolor', all LD plants; also had improvement of vegetative growing under no lighting conditions.

Campanulas kept under short-days produced no flower, but plants lighted, regardless of light source tested, were induced to flowering and reached the requirements for marketing according to the classification criteria of Veiling Holambra (Figure 4B).

The largest number of flowers produced by ‘Champion Pink’, on average 28 flowers per plant, was observed using light of incandescent lamps to forcing while plants kept under light of high pressure sodium produced lower numbers of flowers per plant, on average 18.3 (Figure 5A). There were no significant differences between fluorescent and LED whose flower number per plant was 22.6 and 23.0, respectively. To ‘Champion Blue’ there was no significant difference on number of flowers.

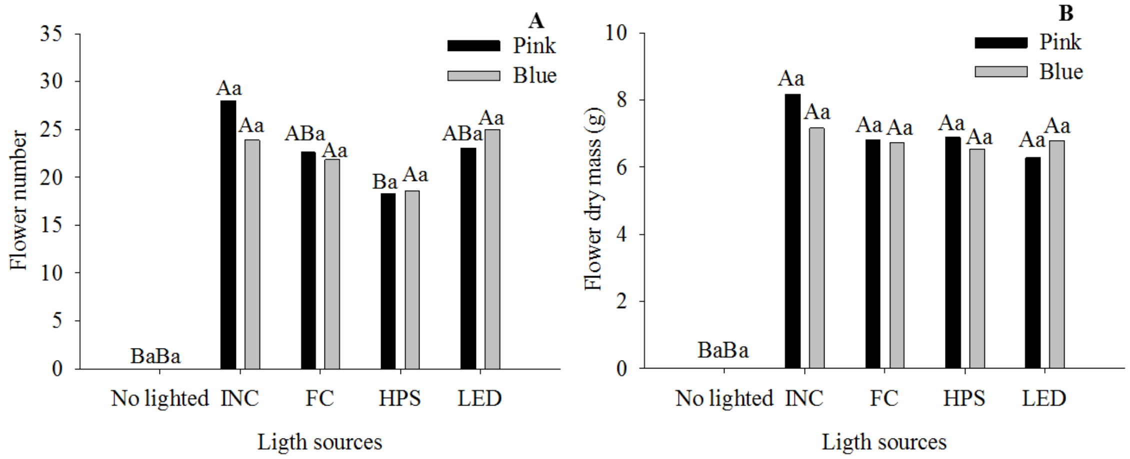


Figure 5. Flower number (A) and Flower dry mass (g) (B) of campanula ‘Champion Pink’ and ‘Champion Blue’ under light emitted by incandescent (INC), fluorescent (FC), high pressure sodium (HPS), light emitting diodes (LED) lamps or no lighted. Same upper case letter comparing lighting sources within each variety and lower case letter comparing varieties within each light source are not significantly different according to Tukey’s test ($P > 0.05$).

There was no difference in flowers dry weight produced by both campanula varieties regardless light source studied, but no lighted plants produced any flowers (Figure 5B). Previous studies reported campanula plants can be grow under natural light during autumn, but the flowering is non-uniform, however, this effect was reduced by the use of continuous lighting with incandescent lamps making possible obtaining campanula potted commercially accepted (Kjaer et al. 2012). Similar to showed in result of this search, *C. carpatica* 'Pearl Deep Blue' and 'Blue Clips', also have no flower production under SD (no lighted) (Runkle and Heins, 2001; Blanchard and Runkle, 2010). Heins and Runkle (2001) reported poor light emission in red region wave spectrum (600-700nm) to occur with cool fluorescent lamps, flower number reduced by 54% in *C. carpatica* 'Blue Clips' and 'Pearl Deep Blue' forced using incandescent or HPS lamps produced in average 26 and 41 flowers, respectively.

There was any significant difference on flower diameter or flower length of ‘Champion Pink’ and ‘Champion Blue’ varieties of campanula in all light sources tested, but theses differentiated of plants no lighted (Figure 6A and 6B). To standardization of campanula potted to Brazilian market there any require to size of flower, but high diameter and length are important for contributing to improvement of ornamental value.

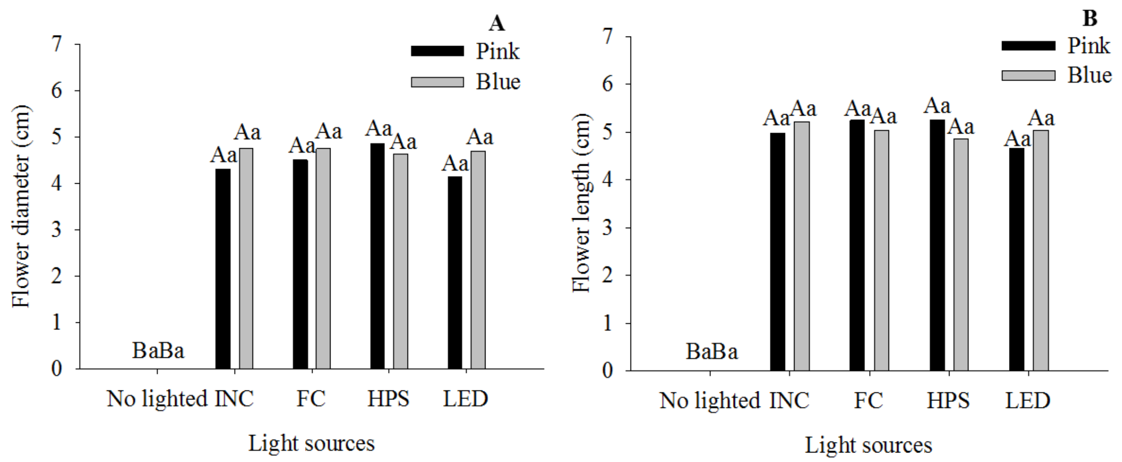


Figure 6. Flower diameter (cm) (A) and Flower length (cm) (B) of campanula ‘Champion Pink’ and ‘Champion Blue’ under light emitted by incandescent (INC), fluorescent (FC), high pressure sodium (HPS), light emitting diodes (LED) lamps or no lighted. Same upper case letter comparing lighting sources within each variety and lower case letter comparing varieties within each light source are not significantly different according to Tukey’s test ($P > 0.05$).

Serek (1991) observed the size flowers *C. carpatica* ‘Karl Foerter’ grown under HPS lamps was proportionally higher according more level light intensity; the size of flowers was important characteristics to improvement of ornamental value of campanula potted, possibly the light supplementation improved the photosynthetic process. Seems the improvement of flowers size is principally affected by environment conditions of plants potted compared to light sources (Grossi et al. 2004; Kjaer et al., 2012).

There was no significant difference in production cycle, period from transplanting seedlings to termination of plants to marketing, in two varieties or light sources studied (Figure 7).

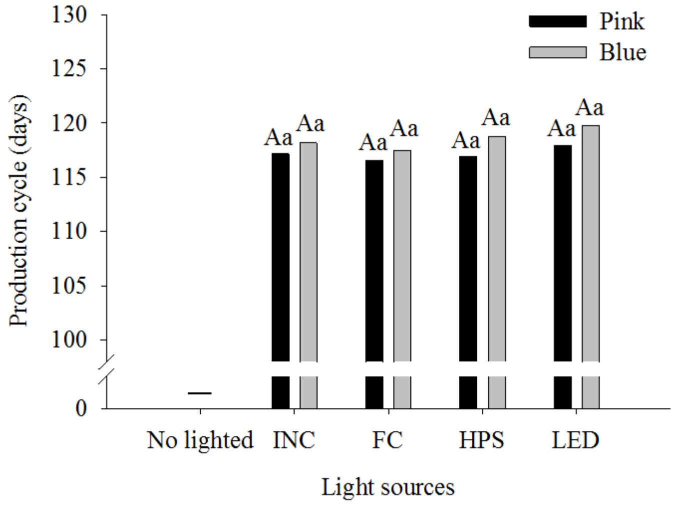


Figure 7. Production cycle (Period from transplanting to commercial stage) of campanula 'Champion Pink' and 'Champion Blue' under light emitted by incandescent (INC), fluorescent (FC), high pressure sodium (HPS), light emitting diodes (LED) lamps or no lighted. Same upper case letter comparing lighting sources within each variety and lower case letter comparing varieties within each light source are not significantly different according to Tukey's test ($P > 0.05$).

Campanulas 'Champion Pink' and 'Champion Blue' potted maintained under SD grow in rosette (Figure 4B); similar to occurred in *C. carpatica* 'Pearl Deep Blue' under same conditions (Runkle et al., 2012). Moe et al. (1991) observed any significant difference on production cycle of *C. isophylla* 'Bla' forced by incandescent or fluorescent lamps in continuous lighting by interrupted night, this period was 96.6 and 90.8 days, respectively. Runkle et al (2012) reported light emitted by incandescent or fluorescent lamps did no effect the time of production of campanula 'Pearl Deep Blue', but others ornamental species as petunia, this effect is more strongly observed. Thus, is necessary to know the more efficient light sources to cultivate each ornamental species.

## CONCLUSIONS

It’s necessary the interruption night to force campanulas ‘Champion Pink’ and ‘Champion Blue’.

To forcing campanulas ‘Champion Pink’ and ‘Champion Blue’ can be use incandescent, fluorescent, high pressure sodium or light emitting diodes (LED).

Is possible the production of ‘Champion Pink’ and ‘Champion Blue’ potted of high ornamental value serving to mark.

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**ARTIGO 2**

# PACLOBUTRAZOL AND DAMINOZIDE ON GROWING CONTROL AND QUALITY OF *Campanula medium* POTTED VARIETIES

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**PACLOBUTRAZOL AND DAMINOZIDE ON GROWING CONTROL AND QUALITY OF *Campanula medium* POTTED VARIETIES**

**ABSTRACT**

Paclobutrazol and daminozide are important growth retardants in floriculture to growth control of potted plant, mainly of species of quick and vigorous development. *Campanula medium* is an ornamental plant that can grow up to 70 to 80 cm, for this is necessary to use growing retardant to control the plants height. Thus, this work aimed to determine a more adequate growing retardant to cultivate of *C. medium* 'Champion Pink', 'Champion Blue' and 'Champions White'. Campanula potted were grown in greenhouse and forced under incandescent lamp. After starting the floral induction, the first group of plants was sprayed with daminozide solutions at concentrations of 1000, 2000, 3000 and 4000 mg $L^{-1}$. The second group of plants was treated with paclobutrazol at concentration of 10, 20, 30 and 40 mg $L^{-1}$ paclobutrazol. The control plants of both experiments were treated with distilled water. The evaluations were performed when 50% of the plants reached the point of sale (three buttons visible). There is liner reduction on dry mass of stem, flowers and leaf, number of flowers and leaf area. The concentration of 40 mg $L^{-1}$ of paclobutrazol or 4000 mg $L^{-1}$ of Daminozide can be used to growth control of campanula 'Champion Pink', 'Champion Blue' and 'Champion White' as potted plants. The studied concentrations produced campanula potted of height ornamental quality, but delay the time of production.

**KEY-WORDS:** inhibitors of gibberellin, Bellflower, Canterbury bells.

**CONCENTRAÇÕES DE PACLOBUTRAZOL E DAMINOZIDE NO CONTROLE DO CRESCIMENTO E QUALIDADE DE VARIEDADES DE *Campanula medium* ENVASADAS**

**RESUMO**

Paclobutrazol e daminozide são importantes retardadores de crescimento usados na floricultura para controlar o crescimento da planta em vaso, principalmente de espécies de desenvolvimento rápido e vigoroso. *Campanula medium* é uma planta ornamental que pode crescer até 70 a 80 cm, assim, é necessário usar reguladores de crescimento para controlar altura. Dessa forma, este trabalho teve como objetivo determinar o retardante de crescimento mais adequado para produção das variedades de *C. medium* 'Champion Pink', 'Champion Blue' e 'Champion White' em vaso. Assim, plantas de campânula foram cultivadas em casa de vegetação e induzidas ao florescimento por iluminação com lâmpada incandescente. Após o início da indução floral, o primeiro grupo de plantas foi pulverizado com soluções de daminozide em concentrações de 1000, 2000, 3000 e 4000 mg $L^{-1}$. O segundo grupo de plantas foi tratado com paclobutrazol, nas concentrações de 10, 20, 30 e 40 mg $L^{-1}$ de paclobutrazol. As plantas controle de ambos os experimentos foram tratadas com água destilada. As plantas características foram avaliadas quando 50% das plantas atingiram o ponto de comercialização. Há redução linear na massa seca de caule , flores e folhas, número de flores e área foliar com o aumento das doses estudadas. A concentração de 40 mg $L^{-1}$ de paclobutrazol ou 4000 mg $L^{-1}$ de Daminozide pode ser usado para controlar o crescimento de campanula envasadas de 'Champion Pink', “Champion Blue' e 'Champion White'. As concentrações estudadas possibilitam a produção de campânulas de vaso de qualidade, mas prolongam o tempo de produção.

**PALAVRAS-CHAVES**: inibidor da giberelina, campânula, flor sino.

**INTRODUCTION**

In floriculture, frequently the growth retardants have been used to the production of potted plants. Growth retardants have an inhibiting effect on division and enlargement cell in plants (Gilbertz, 2002). The growth control by using chemical methods to improve aesthetical effects on potted ornamental plants has been studied for many years. Application of growth retardants is a common practice for commercial growers to achieve attractive compact potted grown plants (Moraes et al., 2005). Two retardants frequently applied on floriculture are the paclobutrazol and daminozide.

Paclobutrazol is an efficient growth retardant used on spraying on several herbaceous plants as chrysanthemum, zinnia, impatiens, and marigold, whoever, studies indicate that paclobutrazol is preferentially translocated through the xylem into plants and accumulates in leaves, however, this growth retardant has a low mobility through the phloem; therefore their efficiency with foliar application is reduced. For this, this compound has more effective when used as drench (Latimer, 2001; Witchard, 1997; Currey et al. 2010). Daminozide is another growth retardant frequently used as spraying control growth in many ornamental species as chrysanthemum, tagetes, impatiens and petunia (Krause et al., 2003; Kazaz et al., 2010).

The genus *Campanula* is an ornamental plant recently domesticated and commercialized in floriculture market. This genus includes about 400-600 species and occurs almost naturally in temperate zone of hemisphere, for example, in the Mediterranean region, the Caucasus and the European Alps (Kuss et al., 2007). This plant has pink, blue, lavender or white flowers coloration and has been cultivated as cut flowers, potted plants or to landscape composition (Bosma and Dole, 2002).

The commercialization of *Campanula medium* has expanded around of world. This plant can grow up to 70 to 80 cm, a very tall plant to be market as a potted plant, for this is necessary to use growth regulator to controlling of height (Dole, 2005). There are few studies to establish the most adequate concentration of growth retardant to cultivate campanula. Pilon (2007) recommended to *C. glomerata* the use of growth retardants B-nine (daminozide), Sumagic (uniconazole) and Bonzi (paclobutrazol) at concentrations 2500 mg $L^{-1}$, 5 mg $L^{-1}$ and 30 mg $L^{-1}$, respectively. Latimer et al. (2001)

reported production of *C. persicifolia* with 30 mg $L^{-1}$ Bonzi and doses less than 5000 mg $L^{-1}$ of B-nine.

However Dole and Wilkins (2005) indicated no concentration of growth regulator to cultivate of campanula; this author reported that the commercial products A-Rest, B-Nine and Bonzi can be efficiently used to cultivate *C. carpatica*; A-Rest to production of *C. isophylla*; to cultivate of *C. persicifolia* and *C. poscharschyana*, A-rest and B-Nine. But same species as *C. Carpatica* 'Clips' and *C. alatines* do not need of growing control.

There is no report on growth retardant to cultivate *C. medium*. Thus, this work aimed to determine the paclobutrazol and daminozide concentrations to control growth and quality of *campanula medium* varieties as potted plants.

## MATERIAL AND METHODS

The seedlings of campanula 'Champion Pink', 'Champion Blue' and 'Champions White', in plugs, used in this experiment were donated by Sakata Seed Sudamerica Ltd Company, when exhibited commercial characteristics to sale. These seedlings were individually transplanted to 1000 ml polyethylene pot capacity and transferred to the greenhouse of Plant Science Department of Federal University of Viçosa, Viçosa - MG. The pots were filled with commercial substrate whose physical and chemical characteristics are described in Table 1.

Table 1. Humidity (H), water retention capacity (WCR), Density (D), pH in water (pH) and electrical conductivity (EC) of commercial substrate used to cultivate of campanula potted.

| **H * (% p/p)** | **WRC (% p/p)** | **D (kg/m³)** | **pH** | **EC (mS/cm)** |
|---|---|---|---|---|
| 60 | 130 | 490 | 5,8(±)0,5 | 2,2(±)0,3 |

* Information of package commercial.

The plants were grown under short-day (SD), at 8 hours of photoperiod, during the first eight weeks; for this, plants were every day covered with opaque blackout cloth from 5:00 pm to 7:00 am, making possible any light throughout the cloth. To flowering forcing plants were transferred to LD, under 16 hours of photoperiod, by broken night by continuous lighting from 10:00 pm to 2:00 am using artificial lighting from incandescent 100W lamps, during three weeks. The light sources were arranged at 80 cm height from the potted plants. Three weeks after beginning of forcing, plants from all treatments were kept under natural day until reach the point to marketing (Veiling Holambra, 2013). The natural photoperiod was calculated by proposed by Thornthwaite & Mather (1955), with the aid of "BHnorm" program established in excel spreadsheet by Rolim et al method. (1998).

The plants were fertilized twice a week with 100 mL fertilized according with the nutrient solution as follows: 54 mg $L^{-1}$ of $NO_3$-N, 1.0 mg $L^{-1}$ of NH4-N, 3 mg $L^{-1}$ of $H_2PO_4$, 31 mg $L^{-1}$ of K, 120 mg $L^{-1}$ of Ca, 15 mg $L^{-1}$ of Mg, 45 mg $L^{-1}$ of $SO_4$, 1.0 mg $L^{-1}$ of Fe, 0.50 mg $L^{-1}$ of Mn, 0.3 mg $L^{-1}$ of Zn, 0.13 mg $L^{-1}$ of Cu, 0.30 mg $L^{-1}$ of B, 0.04 mg $L^{-1}$ of Mo, 45 mg $L^{-1}$ of Cl (Andersen and Hansen, 2002). The watering was daily provided with 100 ml of water per pot. The temperature and relative air humidity were daily registered with datalogger during all production period.

To this work plants were divided in two groups of plants. To the first experiment the plants ‘Champion Pink’, ‘Champion Blue’ and ‘Champions White’ were sprayed with solutions at concentrations of 1000, 2000, 3000 and 4000 mg $L^{-1}$ daminozide. To ensure that the product was applied exclusively on plant canopy, the pot of each pot was covered with blackout cloud to prevent the presence of this regulator in substrate. The second experiment, plants with the same three varieties were treated using 10, 20, 30 and 40 mg $L^{-1}$ of paclobutrazol. Each pot was treated by drenching using an applicator localized directly on substrate. The control plants of both experiments were treated with distilled water. Also to both regulators, the product was spitted in tree applications once a week.

The plant height, flowers number, dry mass of stem, number or flowers, length and diameter of flowers, number of leaves, dry mass of leaves, leaf area, cycle (for the period from transplanting to the point of sale) was evaluated. The evaluations was realized when 50% of plants reached the commercial point in according classification rules for potted campanula of Veiling Holambra (Veiling Holambra, 2013).

The experimental design of both experiments was completely randomized in a 3x5 factorial (varieties x concentrations) with 5 replicates. Data were subjected to analysis of variance and polynomial by F test at 5%.

## RESULTS AND DISCUSSION

The production cycle corresponded to 09 July to 18 August period. During this period the average temperature was from 12.5 °C to 24 °C and the relative humidity was between 96% and 59% (Figure 1).

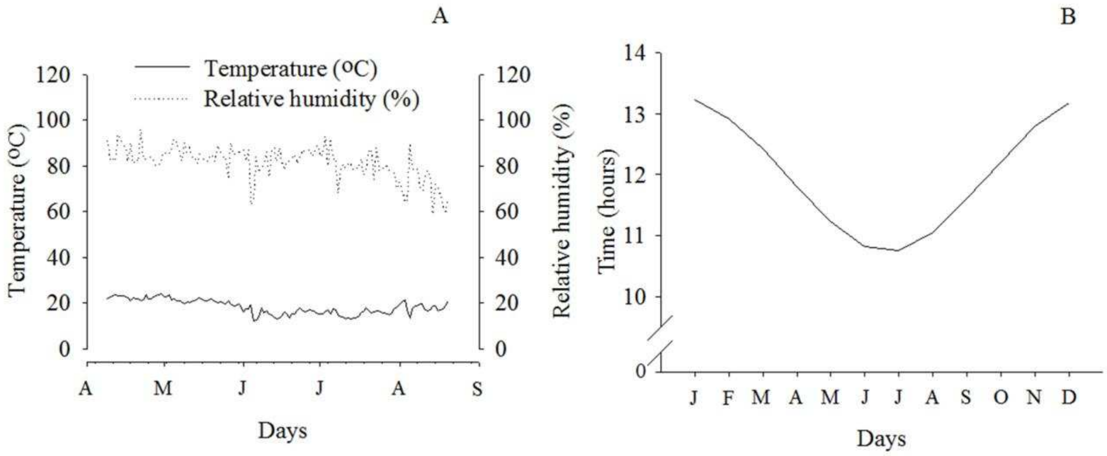


Figure 1. Average relative air humidity (%) and average temperature (°C) during production of campanula potted (A) and natural photoperiod in cultivate area in Viçosa, MG.

There was significant effect of growth retardant to control plant height of campanula potted. The paclobutrazol reduced the height plants to approximately 40.8%, 42.7% and 46.3% in ‘Champion Pink’, ‘Champion Blue’ and ‘Champions White’, respectively varieties (Figure 2).

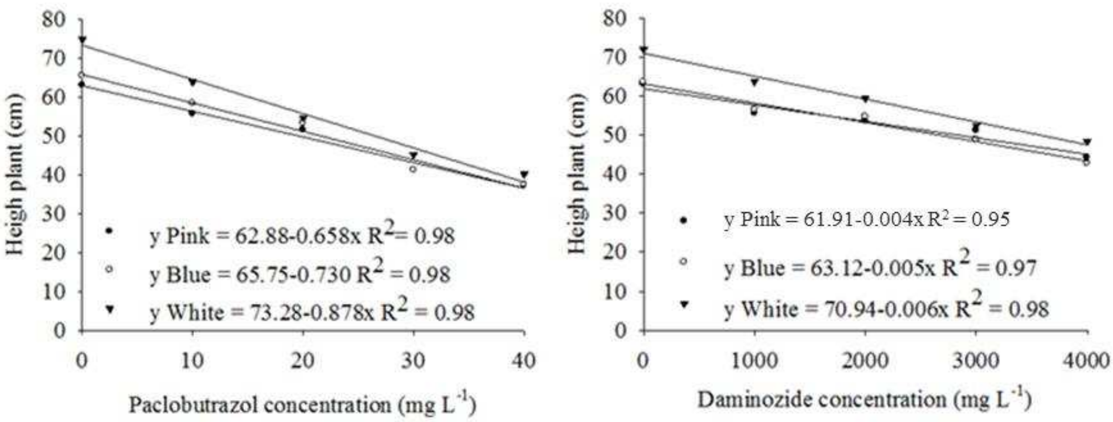


Figure 2. Plant height of *Campanula medium* ‘Champion Pink’, ‘Champion Blue’ and ‘Champion White’ varieties, grown in pot treated with Paclobutrazol or Daminozide.

The daminozide had lower effect in controlling growth of campanulas plants and reduced the height of plants only 29.8%, 32.8% and 32.8% in varieties ‘Champion Pink’, ‘Champion Blue’ and ‘Champion White’, respectively. The height of development plants was more pronounced to ‘Champion White’ variety compared to 'Champion Pink' and ‘Champion Blue’, but the plants height was reduced with increasing concentrations of either growth retardant tested.

Many studies have shown that paclobutrazol, belonging to triazol chemical group, inhibits the enzyme ent-kaurene oxidase that acts on first step of gibberellins synthesis process, converting the ent-kaurene to ent-caurenoic. The Daminozide, however, belongs the derivatives of acylcyclohexanedione chemical group, and has effect on later steps of gibberellin biosynthesis involving hydroxylases, enzymes responsible for converting $GA_{12}$ and $GA_1$ to the aldehyde. Both growth retardant act to reduce the levels of gibberellins in plants and consequently reduce the plant height (Rademacher, 2000).

There are few studies on the adjustment of growth retardant concentrations to growth control of potted campanula. Hammer (1992) reported to commercial production of *C. isophylla* is necessary to use 2500-5000 mg $L^{-1}$ B-nine (daminozide) sprayed, however, the concentration of 10000 mg $L^{-1}$ cause phytotoxicity. Dole and Wilkins (2005) mentioned the possible use of triazoles for controlling plant height, but recommended any concentration of these products. Serek (1991) studied cultivated *C. carpatica* 'Karl Foerster' using 50 mg $L^{-1}$ paclobutrazol as foliar spray, but Barrett et al. (1994) has been shown that on ornamental plants this growth retardant is more effective when applied by drenching.

There was no significant difference in the dry mass of stems between the varieties when treated with paclobutrazol or daminozide (Figure 3). However, was observed a small decreasing to dry mass when higher doses of growth retardant were used.

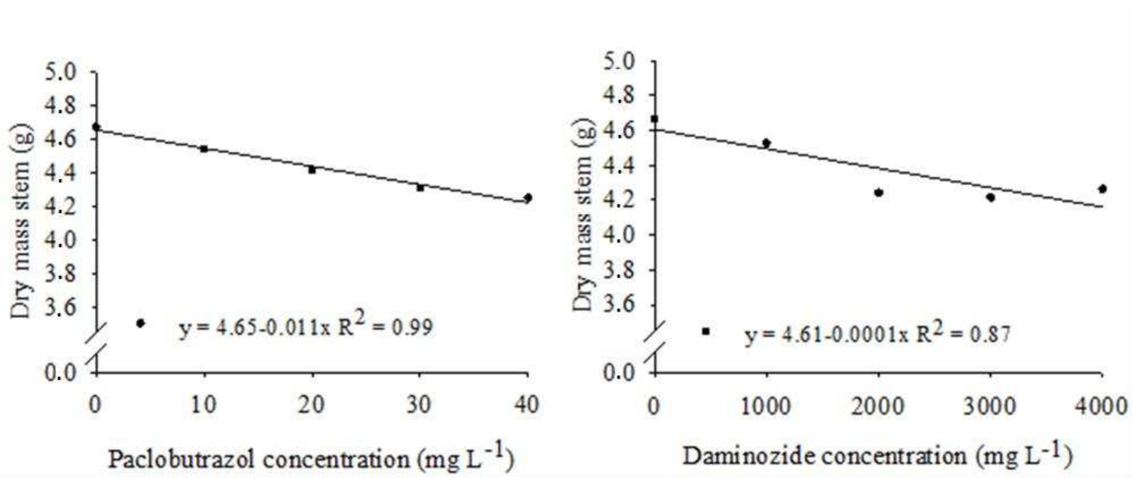


Figure 3. Stem dry mass of *Campanula medium* varieties ‘Champion Pink’, ‘Champion Blue’ and ‘Champion White’, grown in pot treated with Paclobutrazol or Daminozide.

The reduction of stem dry mass production was frequently observed in ornamental plants as, for example, sunflower (Bonacin et al. 2006). Plants of *Zinnia elegans* 'Lilliput' treated with daminozide also had the stem dry weight reduced when treated with daminozide (Pinto et al., 2005). Concentrations of 5000 mg L$^{-1}$ of daminozide and 30 mg L$^{-1}$ of paclobutrazol reduced the chrysanthemum stem dry mass from 1.8 g (control) to 1.0 g and 0.9 g, respectively (Gilbertz, 2002). According Tsegaw et al. (2005) the reduction of stem dry matter may be associated with lower levels of gibberellins in plants grown which reduce cell elongation and alter the anatomy of stems.

The Paclobutrazol reduced the number of flowers produced by ‘Champion Pink’, ‘Champion Blue’ and ‘Champion White’ up to 24.3%, 23.0% and 17.6, respectively (Figure 3).

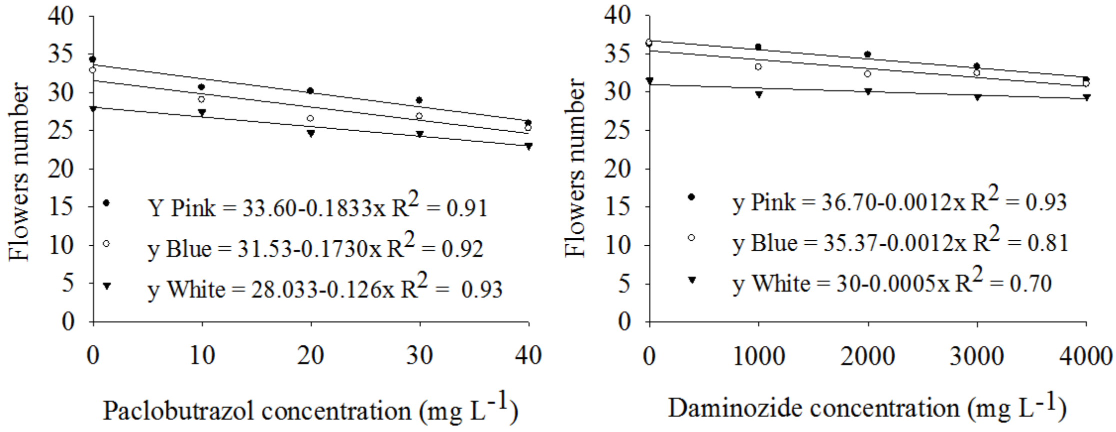


Figure 4. Number of flowers of *Campanula medium* varieties 'Champion Pink', 'Champion Blue' and 'Champion White', grown in pot treated with Paclobutrazol or Daminozide.

The plants treated with daminozide the number of flowers had reduced up to 12.9%, 14.8% and only 6.7% in varieties 'Champion Pink', 'Champion Blue' and 'Champion White', respectively (Figure 3). It was observed that the variety 'Champion White' had a lower number of flowers in all concentrations, a characteristic of this variety.

There is no previous study on the application of growth retardant on number of flowers produced by plants campanulas. Bosma and Dole (2002) reported that all varieties of *C. medium* produced above 10 flowers per raceme. *C. carpatica* 'Karl Foersters' produced the maximum of 28 flowers e *C. carpatca* 'Dark Blue' produced 42-62 flowers per plant, both without the use of growth retardant (Serek, 1991; Andersen and Hansen, 2002).

Francescangeli and Zagabria (2008) used increasing concentrations of paclobutrazol to control height of petunia cultivar Bravo F1, whose flowers were of blue, red and white coloration (variations of same-cultivate that not differ in vegetative state). These authors observed that the highest concentrations (15 mg $L^{-1}$) of paclobutrazol reduced the number of open flower in plants of blue and red color, but have no significant difference to plants with white flower colors.

The diameter and length of flowers have no significant difference in all variety or concentrations of growth retardant tested. In average the diameter and length of flowers were 4.5 cm and 4.3 cm respectively. This information is important because indicates that the use of growth retardant does not affect the ornamental value of campanula potted. Serek (1991) reported the size of flower is an important characteristic to determine the decorative value and can be used to classification of campanula 'Karl Foerster' potted. The diameter of flowers is according with studied by Niu et al (2001) that observed a variation between 3.0 cm and 5.0 cm in flowers diameter of *C. carpatica* 'Blue Chips'.

The dry mass of flowers was reduced by plants cultivated using paclobutrazol in 25.0%, 30.6% and 31.2% to 'Champion Pink', 'Champion Blue' and 'Champion White', respectively (Figure 5). Whereas to treated using daminozide the dry mass of flowers were reduced by 34.7%, 30.6% and 31.5%, respectively.

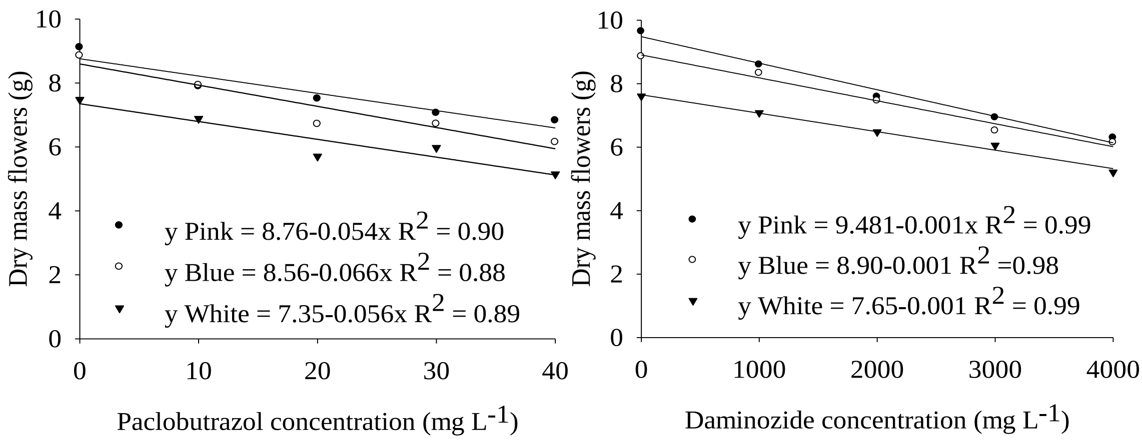


Figure 5. Dry mass of flowers of *Campanula medium* varieties 'Champion Pink', 'Champion Blue' and 'Champion White', grown in pot treated with Paclobutrazol or Daminozide.

There was no significant statistic difference on leaf number produced in campanula plants, regardless of variety or concentrations of both growth retardant studied. On average all the plants produced an average of 18 leaves per plant.

Although there is no quantitative to number of leaves produced, this characteristics is important to classification of campanula because the presence of leaves is required for standardization of potted plants according to criteria of standardization proposed to potted campanulas of Veiling Holambra (Veiling Holambra, 2013).

There was no significant difference to dry mass of leaves produced among varieties. Increasing the concentrations of paclobutrazol the dry mass of leaves was reduced in up 15.8% whereas the maximum reduction caused by daminozide was around 12% (Figure 6). The leaves of campanula have pronounced petiole, his structure was responsible to variation on dry mass of leaves because on higher concentration they presented shorter.

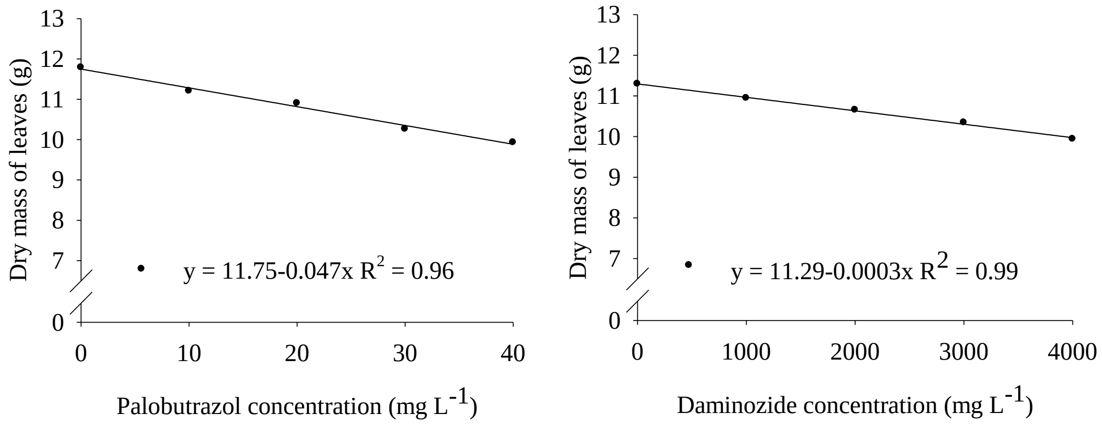


Figure 6. Leaves dry mass of *Campanula medium* varieties 'Champion Pink', 'Champion Blue' and 'Champion White', grown in pot treated with Paclobutrazol or Daminozide.

The paclobutrazol reduced the area of leaves of campanula plants in up to 13.9%, whereas the daminozide caused the reduction in up to 14.3% (Figure 7). The effect of growth retardant on reduction of area of leaves on plants has been reported. According Lolaei et al (2013), the increasing of growth retardant concentration decrease the leaf area of many species. The ornamental plant Lantana had the leaves reduced in 75% when treated with paclobutrazol 50 mg $L^{-1}$ (Matsoukis et al., 2004). Ozgur (2011) observed 50% and 26% of reduction on area leaves of cucumber seedless using 500 and 1000 mg $L^{-1}$.

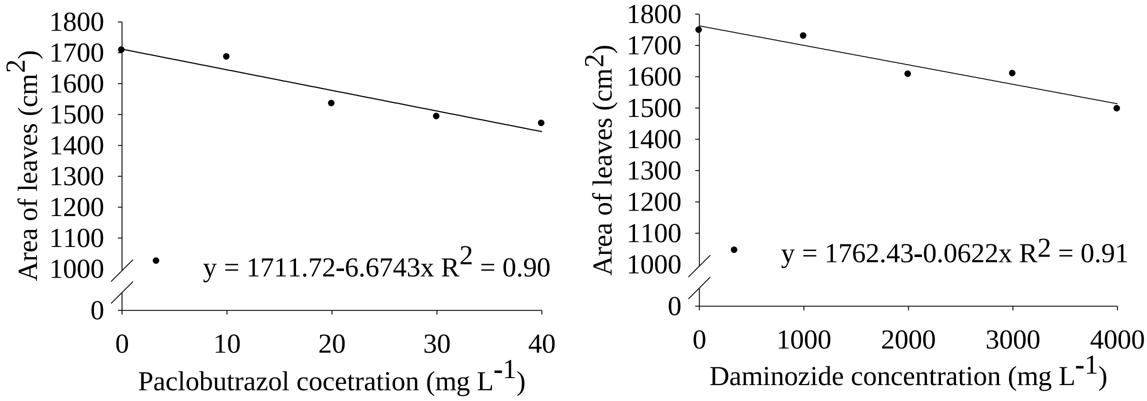


Figure 7. Area of leaves of *Campanula medium* varieties 'Champion Pink', 'Champion Blue' and 'Champion White', grown in pot treated with Paclobutrazol or Daminozide.

The use of the highest paclobutrazol concentration delayed the cycle of cultivation of campanula potted in more of ten days and the highest daminozide concentration in five days. There was no significant difference on cycle cultivate to the different varieties studied (figure 8).

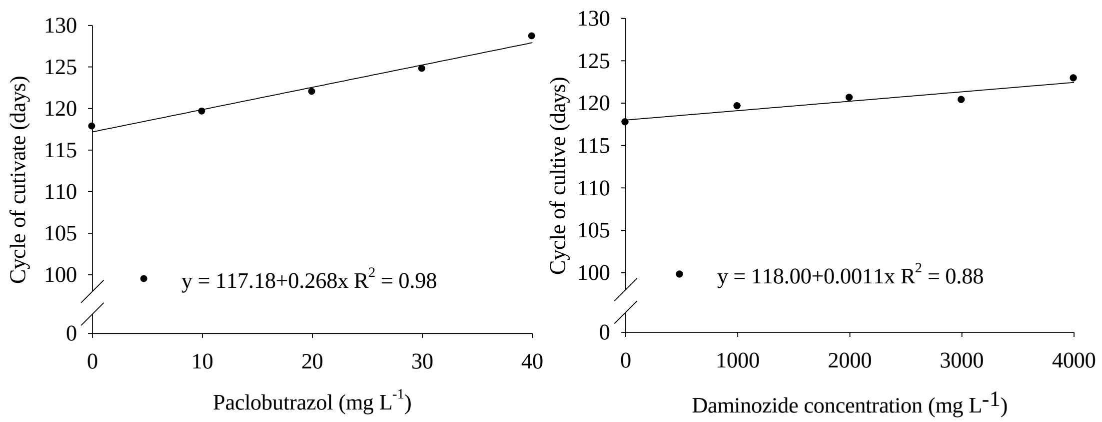


Figure 8. Cycle of cultivate of *Campanula medium* varieties 'Champion Pink', 'Champion Blue' and 'Champion White', grown in pot treated with Paclobutrazol or Daminozide.

According Dole and Wilkins (2005) *C. isophylla* and *C. carpatica* have cycle production of 140 to 182 days, in countries of tempered climate, but in places of elevated temperature the cycle can be faster (Niu et al, 2001). The production of *C. carpatica* 'Carpathian bluebell' have the cycle complete in 132 days without using of growth retardant (Andersen and Hansen, 2002). There was no previous report on application of growth retardant on cycle cultivate, but the delay in time production caused by this chemical products had been reported. The application of 15 mg $L^{-1}$ of paclobutrazol on petunia delayed the time finalization of plants compered to control plants (Francescangeli and Zagabria, 2008). Kazaz et al. (2010) reported 3000 mg $L^{-1}$ of delay the time of flowering of chrysanthemum.

**CONCLUSIONS**

The concentration of 40 mg $L^{-1}$ of paclobutrazol and 4000 mg L of Daminozide can be used to growth control of campanula varieties ‘Champion Pink’, ‘Champion Blue’ and ‘Champion White’ as potted plants.

There is liner reduction on stem, flowers and leaf dry mass, also number of flowers and leaf area to paclobutrazol and daminozide.

The studied concentrations don’t affect the ornamental quality of campanula potted, but delay the time of production, but this no affect the production.

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## ARTIGO 3

# POSTHARVEST OF BELLFLOWERS CUT FLOWERS TREATED WITH PULSING OF SUCROSE

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**POSTHARVEST OF BELLFLOWERS CUT FLOWERS TREATED WITH PULSING OF SUCROSE**

**ABSTRACT**

***Campanula medium,* popularly known as bellflowers, belonging to Campanulaceae family, is marketed as potted flowers or cut flowers. In cut flowers due to senescence process often is necessary to add sources of carbohydrates in the solution pulsing to respiration maintenance and the osmotic regulation. Therefore, the aim of this study was to determine the concentration of sucrose in pulsing treatment on the conservation of bellflower stems. Thus, 'Champion White' bellflower stem flowers were standardized with 60 cm length and 15 to 20 opened flowers and treated individually for 24 hours in pulsing solution of sucrose at concentrations of 0%, 1%, 3% and 5%. The stems were transferred to vases containing 200 ml of tap water and kept until the end of vase life. Daily the water uptake, fresh weight loss of stems, SPAD index of leaves and flower longevity were evaluated. The higher water absorption was observed in stems treated with 5% sucrose. Weight loss occurred at first 24 hours after treatment pulsing, in all sucrose concentrations. However, at concentrations of 1% and 3% the weight of the stems were constant until the end of vase life. The flower stems treated with 1% kept the SPAD index, that measure the green coloration of the leaves, for longer period when compared with the other treatments. The longest vase life of 6.8 days was observed in stem flowers treated with 1.0% and lower longevity of 3.6 days was obtained from stems treated with 5% sucrose in pulsing solution.**

**Keywords**: *Campanula medium*, water uptake, longevity, canterbury bells, vase life.

## INTRODUCTION

*Campanula medium*, known as bellflower or canterbury bells, belonging to Campanulaceae family, is an ornamental species grown as potted flowers or as cut flowers presenting high ornamental value (Serek, 1991). The stem flowers of bellflowers have 75 cm long with 10 or more flowers; commercially varieties with flowers of blue and pink color are most used (Bosma and Dole, 2002).

The vase life of cut flowers depends of the reserves stored in stems and to extend vase life of many species is necessary add carbohydrates sources in the pulsing solution such as sucrose (Spricigo et al., 2010a; Almeida et al., 2011). There is evidence that sucrose acts in tissue osmotic control and delaying senescence; many studies have reported that sucrose is effective in prolonging the vase life of many ornamental species, but not all (Yakimova et al., 1997, Cho et al., 2001; Carneiro et al., 2002; Brackmann et al., 2004, Spricigo et al., 2010b, Vieira et al., 2011).

Bosma and Dole (2002) found that sucrose did not extends significantly the vase life of bellflower; when stem flower are pulsed with 0%, 5% or 10% sucrose the vase life was 9.1, 7.8 and 8.8 days, respectively. These authors reported that effect of sucrose on extending the vase life was more efficient combining pretreatment with 1-MCP or water heated to 35°C. Scariot et al. (2008) studied the bellflowers *C. barbata, C. latifolia*, *C. rapunculoides* and *C. Trachelium* and observed that the use of 1-MCP, an effective blocker of ethylene perception, extended the vase life of flowers but the application of exogenous ethylene had no effect on longevity.

Sucrose has low-cost and easy accessibility, so it has been in many pulsing solutions combined or not with other products such ethylene inhibitors. But few are the reports on effect of sucrose on the bellflowers vase life. The aimed of this work was to determine the best sucrose concentration in pulsing on the conservation of bellflowers stem.

## MATERIAL AND METHODS

'Champion White' bellflowers plants were grown in pots containing commercial substrate maintained in greenhouse. The stems flower were harvested at 8:00 AM with

50% of opened flowers and placed in containers with tap water. The stems with 17 to 23 flowers were standardized with 60 cm length.

After standardization, the stems were pulsed individually in 200 ml of sucrose solution at concentrations of 0%, 1%, 3% and 5% for 24 hours. Then they were all individually transferred to a polyethylene vase containing 200 ml of water until the end of vase life. The water of vase was changed every day. It was considered the end of bellflowers vase life when 50% of flowers had any symptoms of senescence such as wilding or browning (Bosma and Dole, 2002). Morphological changes were daily observed and documented using datalogger model HT-4000.

Stem flowers were stored at room temperature and 12 hours photoperiod at 410 lux. The room temperature during bellflowers vase life varied from 22.8°C to 28.1°C and relative humidity ranged from 64.1% to 67.4%.

The stem fresh mass were daily evaluated. The variation of weight was expressed as a percentage relative of initial fresh mass according proposed by Vieira et al. (2011). The water uptake was obtained for volume of consumed and calculated by the following formula V = (IWS-FWS/FWF) where:

V: volume consumed (mg.gFW$^{-1}$.dia$^{-1}$);

FWS: final weight solution (mg);

IWS: initial weight solution (mg);

FWF: final weight stems flower (mg).

The SPAD index was obtained using the chlorophyll meter model SPAD-502 in leaves bellflowers was daily measured on three different leaves from middle region of stems. To all evaluations the same leaves were taken using a portable chlorophyll meter SPAD-502 (Soil-Plant Analysis Development-502)

The change that occurred in flowers, leaves and stem during vase life that caused loss of ornamental value were daily recorded.

**RESULTS AND DISCUTION**

The concentration of 1.86 % enable the larger 6.53 days of bellflower longevity (Fig. 1). The stems pulsed with 5% sucrose solution exhibited browning and dehydration symptoms on edge of petals and foliage (Fig. 2).

The stems treated with 0% of sucrose presented symptoms of wilting only after 3 days postharvest; browning the petals edges (Fig. 2). The presence of edges dehydrated in bellflowers treated with 5% sucrose at first at 24 hours of pulsing; infer that this concentration can be high, because no senescence symptoms in other concentrations were observed, in the same time.

The wilting, and browning of edges of flowers are symptoms of senescence observed during bellflowers vase life. Bosma and Dole (2002) found that browning is common in bellflowers postharvest and this is a parameter for evaluating ornamental quality loss. These authors also reported that high concentrations of sucrose can cause high percentage of flower senescence. Similar symptoms to those were also reported by Delaporte et al. (2000); they observed that 5% sucrose induced leaf browning following dehydration. This suggests that the browning of edges during bellflower postharvest can be induced by the loss of water through the petals, sepals and foliage via transpiration or by osmotic effect, the lowest water content in these organs initially causes loss of turgor of which later is shown browning (Almasi et al. 2012).

High water uptake in stems treated with 0% sucrose was observed (Fig. 3). Lowest water uptake was observed at 1% and 3% sucrose solution. The stem fresh weight decreased in first 24 hours after pulsing in all treatments, but the largest decreasing occurred in stems treated with 5% sucrose (Fig. 4). After 24 hours, the stems treated with 1% or 3% sucrose the decreasing of stem fresh weight was more subtle and remained almost constant until the end of vase life. Low sucrose concentration maintains the turgidity of bellflower stems, but high concentrations were harmful and caused rapid dehydration of flowers.

The SPAD index decreased for all treatments, but when bellflowers were treated with 5% sucrose presented lower indexes (Fig. 5). During leaves senescence there is tendency to decrease the index SPAD due to loss of green color caused by the degradation of chlorophyll from leaves (Fan et al. 2,009). Stems pulsed with 5% sucrose solution presented senescence symptoms early, but visually little variation of green coloration of leaves was observed. A little variation in the SPAD index was observed in stems treated with 1% sucrose solution; but concentrations of 0% and 3% expressive reduction was observed. Kazemi and Ameri (2012) reported that use of sucrose in postharvest lily cut flower increased the SPAD index and the longevity. These authors reported that exogenous carbohydrate would be enough to delay the senescence, considering that they maintain the metabolism of cut stem flowers. It is possible that similar effects occurred in treating pulsing with exogenous sucrose in flowers bellflowers effecting longevity.

## CONCLUSION

Bellflowers exhibited longer longevity, 6.8 days, when treated with sucrose 1,86%.

There was a marked weight loss of stems in the first 24 hours in all treatment but stem flowers treated with sucrose 1% and 3% there was little change.

The flower stems pulsed with sucrose 1% kept the SPAD index for longer period.

The pulsing using sucrose 5% for 24 hours caused speed wild and chlorosis symptoms, so is not recommended to pulsing treatment of campanula cut flower.

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**FIGURES**

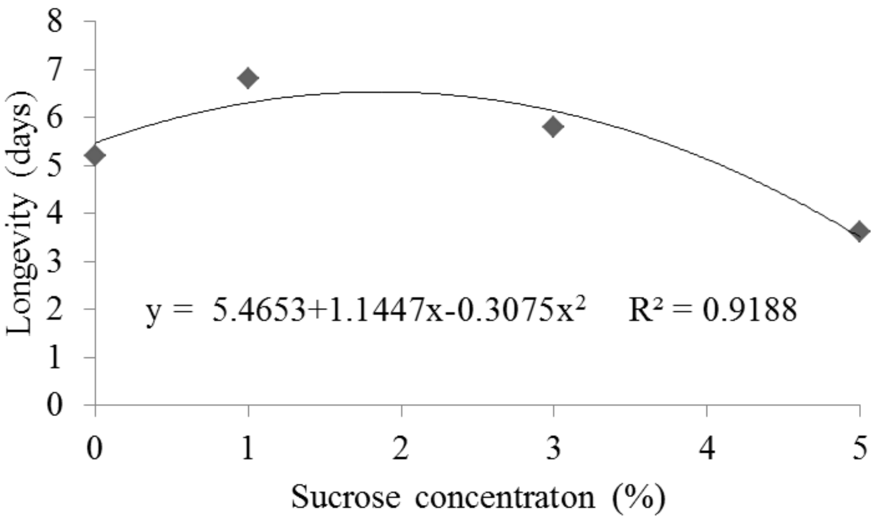


Fig. 1. Longevity of bellflowers pulsed with sucrose 0%, 1%, 3% or 5% of for 24 hour. Means followed of same letter did not differ significantly by Tukey test at 5% probability.

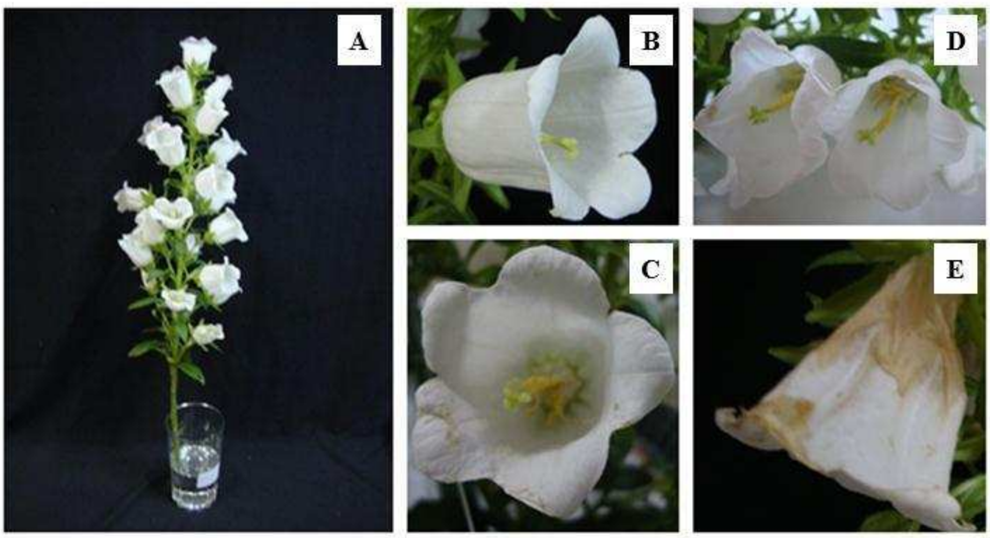


Fig. 2. Symptoms of senescence bellflowers variety ''white' during vase life. General view of stem flower (A), flower development stage at harvest (B), flower presenting beginning of browning on edges petals after 24 hours of pulsing in solution with 5% (C) flowers pulsed with 0% sucrose presenting wilting after 3 days of vase life (D), flower without ornamental value with wilt and browning in more than 50% of petal surface (E).

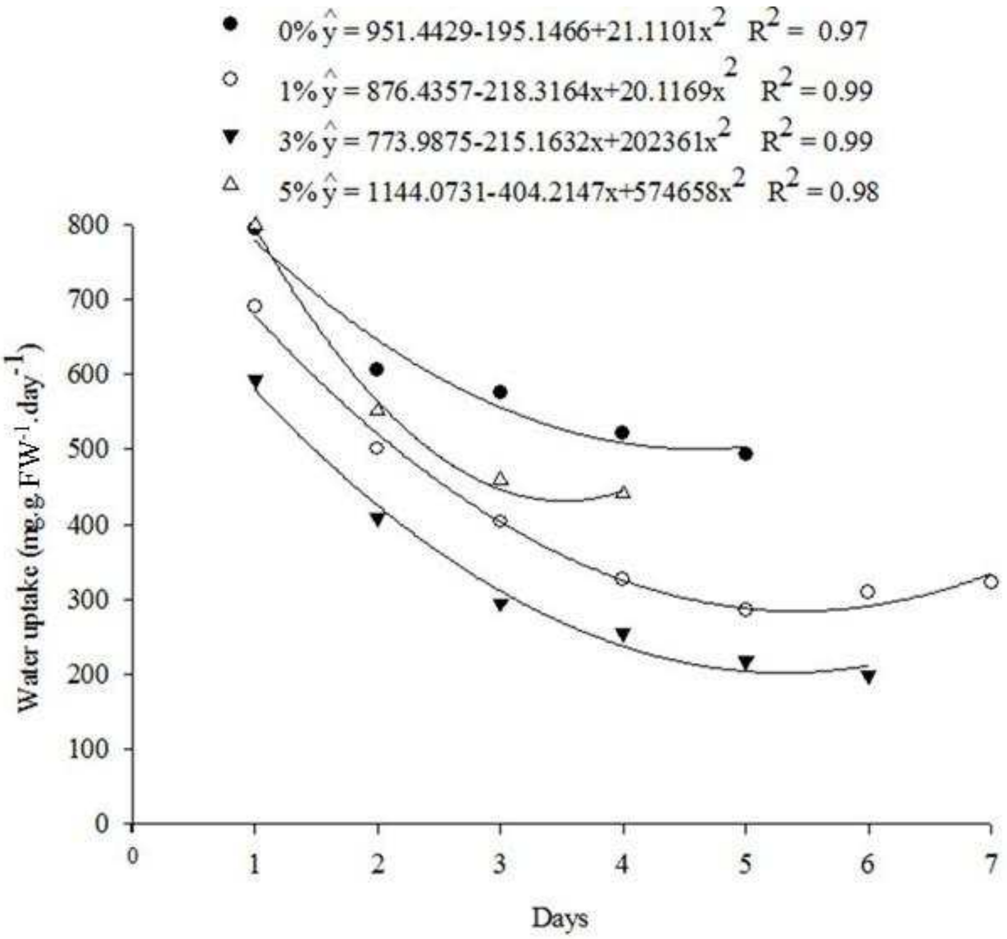


Fig. 3. Water uptake of bellflowers pulsed with sucrose 0%, 1%, 3% or 5% of for 24 hour.

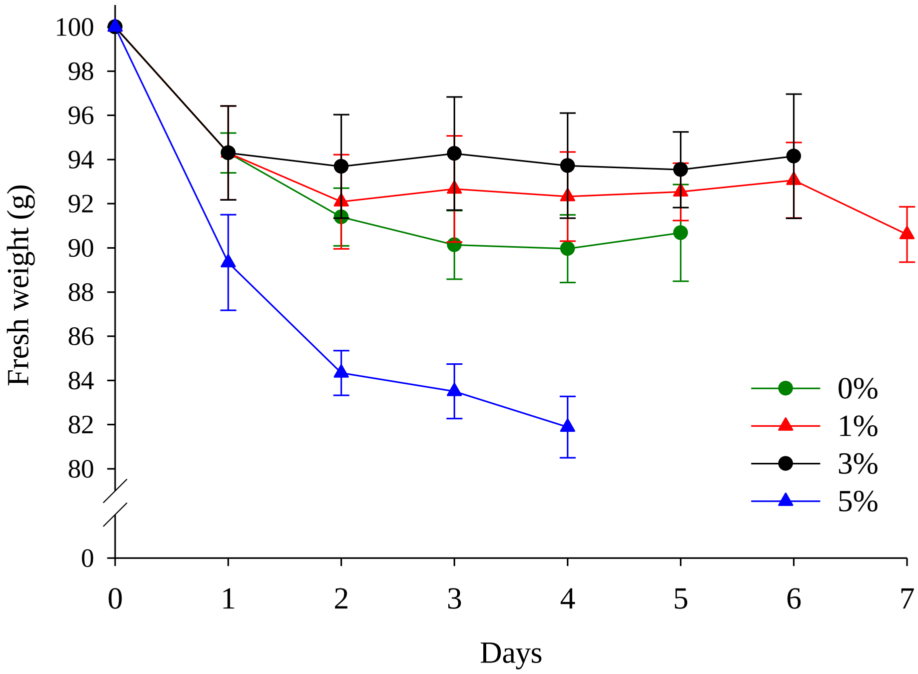


Fig. 4. Percentual change in fresh weight of bellflowers pulsed with sucrose 0%, 1%, 3% or 5% of sucrose for 24 hour. Bars represent standard error.

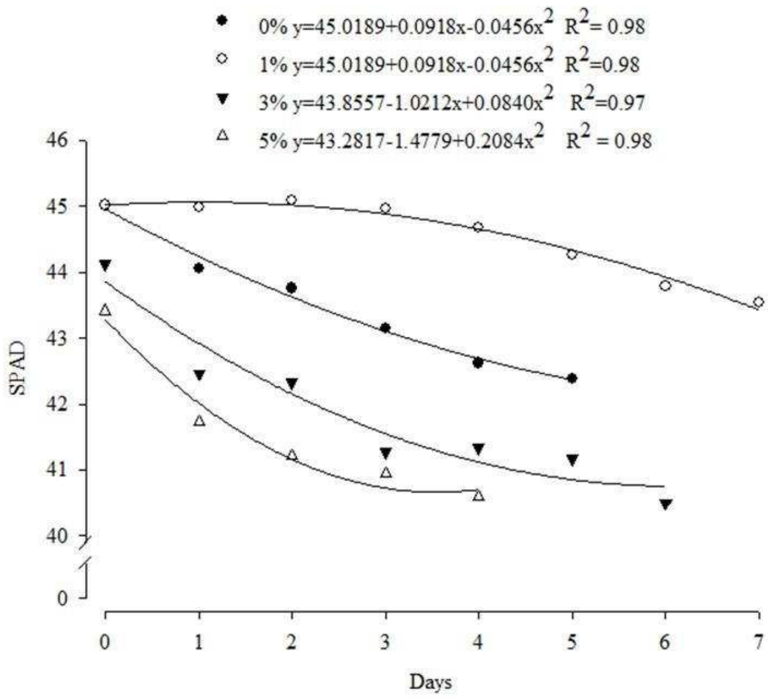


Fig. 5. SPAD index of leaves of bellflowers pulsed with sucrose 0%, 1%, 3% or 5% of for 24 hour.

# ARTIGO 4

## FIRST REPORT ON Sclerotinia sclerotiorum ON Campanula medium IN BRAZIL

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Nota científica formatada segundo as normas editoriais da Revista Plant Disiese.

**FIRST REPORT ON *Sclerotinia sclerotiorum* ON *Campanula medium* IN BRAZIL**

**ABSTRACT** – In Viçosa-MG was observed the first occurrence of *Sclerotinia sclerotiorum* causing loss of ornamental quality in *Campanula medium* 'Champion Pink, 'Champion Blue' and 'Champion White' on 20%, 22% and 7%, respectively. The *S. sclerotiorum* infection was started by edges leaves developing along of leaf, preferably over the vascular bundles. The most severe damage occurs after fungi infect stem flower causing annealing and following to growing mycelial like white cotton aspect. Late, the wilting, damping-off and loss of quality ornamental plants was observed. The presence of sclerotia, structures of resistance, typical characteristic of disease, also was observed.

Index terms: Canterbury bells; bellflowers; disease, photoperiod; floriculture, white mold.

**Primeiro relato de *Sclerotinia sclerotiorum* em *Campanula medium* no Brasil**

Resumo - Em Viçosa-MG foi observada a primeira ocorrência de *Sclerotinia sclerotiorum*, causando perda de qualidade ornamental em *Campanula medium* ‘Champion Pink', ‘Champion Blue’ e ‘Champion White' em 20%, 22% e 7%, respectivamente. A infecção por *S. sclerotiorum* se iniciou nas bordas das folhas se desenvolvendo ao longo da folha, preferivelmente ao longo dos feixes vasculares. Os danos mais graves ocorreram depois que os fungos infectam o rácemo floral causando anelamento, seguindo para o crescimento micelial com aspecto cotonoso. Logo após, o murchamento, ocorreu o tombamento e perda da qualidade ornamental das plantas. A presença de escleródios, estruturas de resistência, característica típica da doença, foi também observada.

Termos de indexação: Sinos de Canterbury, campânulas, doença, fotoperíodo, floricultura, mofo branco.

The Campanulaceae family includes annual or perennial species of high ornamental value. The genus Campanula includes approximately 600 naturally occurring species in the temperate zone of the northern hemisphere, especially in the

Mediterranean region, the Caucasus and European Alps (Kuss et al., 2007). Popularly known as Canterbury bell or campanula, this plants present flowers bells-type of pink, blue, lavender and white color and these been cultivate as cut flowers or potted plants (Bosma and Dole, 2002).

Many campanulas are produced to flower market. Of these, the species *Campanula medium*, recently introduced in Brazil, has been a new alternative option for producers of ornamental plants noted for their beauty and color of flowers (Gioria et al., 2010). This species has been most often marketed as a potted plant, but has also been accepted as a cut flower. However information on technical cultivates, pests and diseases incidence on campanulas cultivated still are little known.

In cropping systems of ornamental plants the diseases occurrence is one of more important causes of losing during plant cultivate and post-harvest stages. This is because these products are valued by visual appearance and any structure or characteristics that contribute to loss quality can lead to rejection, of all lots by, the consumer. The criteria to classification of campanula potted proposed by Veiling Holambra (2013), the largest warehouse to flower and ornamental plants sale of Brazil, report pathogenic infections is a characteristics for classifying campanula potted.

Although the symptoms of infection by phytopathogenic organisms are not well characterized in campanula plants, the Canadian Phytopathological Society reported the *Fusarium sp*. and *Sclerotinia sclerotiorum* occurrence causing rotting of roots and stalks of campanula plants, respectively (Morrall, 2010). According Dole et al. (2001), *Rhizoctonia solanii* also causes rotten on rot and Botrytis leads to losing quality of plants due drying flowers. In Brazil, one of the diseases commonly seen on ornamental plants such as sunflower, aster and eternal flowers is the white mold, caused by *Sclerotinia sclerotiorum* (Leite, 2005; Bueno et al., 2006, Duarte and Barreto, 2009). This pathogen is very aggressive and causes loosing production and dead different parts of plants.

Due the recently introduced of campanula as cultivate plants in Brazil, there are any report on incidence of fungi diseases causing loosing production. Therefore, this study aimed quantify and describe the symptoms of *Sclerotinia sclerotiorum* infection in *Campanula medium*.

In Viçosa-MG in area production of 'Champion Pink', 'Champion Blue' and 'Champion White' of *Campanula medium*, in Federal University of Viçosa, the first occurrence of *Sclerotinia sclerotiorum* was detected. The infection occurred in July 2011, in plants grown in pots filled with commercial substrate and kept in greenhouse.

To isolation was performed by an indirect method of fungus in a Petri dish containing culture medium vegetable broth - agar (CVA) + streptomycin sulfate. These were kept in an incubator and the fungus grew quickly. The structures formed were observed under an optical microscope and only consisted of sterile mycelium. Later in culture and in plant material was observed Sclerotia formation typical for the genus *Sclerotinia*. Was made the DNA extraction using the Wizard® Genomic DNA Purification kit, according manufacturer's instructions. The internal transcribed spacer (ITS) region PCR was performed with primers ITS4 and ITS5. Purification and sequencing were performed by Macrogen company. The sequences obtained were compared with the sequences deposited in GenBank and confirmed the identity of fungi as *Sclerotinia sclerotiorum*.

The plants were infected at beginning of flowering (13 weeks after transplanting), with an incidence of 49% of the plants causing loss of ornamental quality and death of 16% of stand infected. The frequency was obtained by direct count from 550 plant potted cultivate.

Analyzing the historic of production in area actually used to campanula production, was found that in September 2008, the incidence of *Sclerotinia sclerotiorum* caused stem rot in plants of eternal flowers, was reported (Duarte and Barreto, 2009). The greenhouse used for cultivate was constructed in same area. Due sclerotia remain in the soil for several years, it is possible that campanulas plant infestation occurred by resistance structures present in the soil resulting from infestation occurred in 2008 (Duarte and Barreto, 2009).

Was observed the occurrence this pathogen mainly in 'Champion Pink' and 'Champion Blue' with 20% and 22%, respectively (Figure 1). In the variety 'Champion White', there were incidences of only 7%.

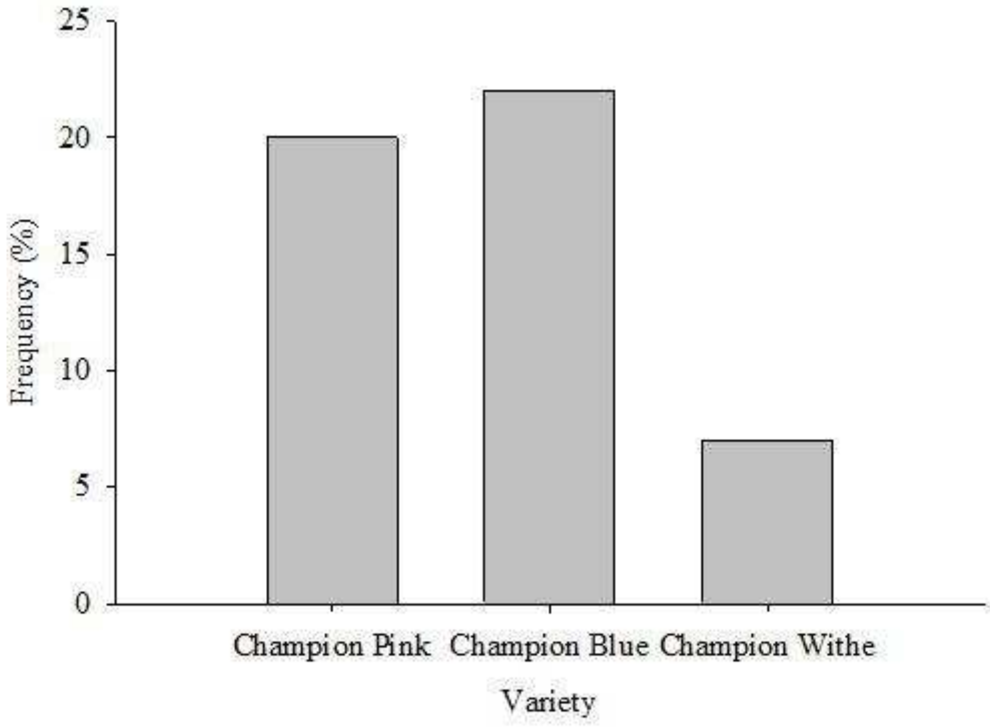


Figure 1. Frequency *C. medium* 'Champion Pink', 'Champion Blue' and 'Champion White' infected by *S. sclerotiorum*.

The *S. sclerotiorum* infection was started by edges leaves in necrotic areas resulting from nutritional disorders, possibly due sclerotia transported by wind from contaminated soil above the region (Figure 2A).

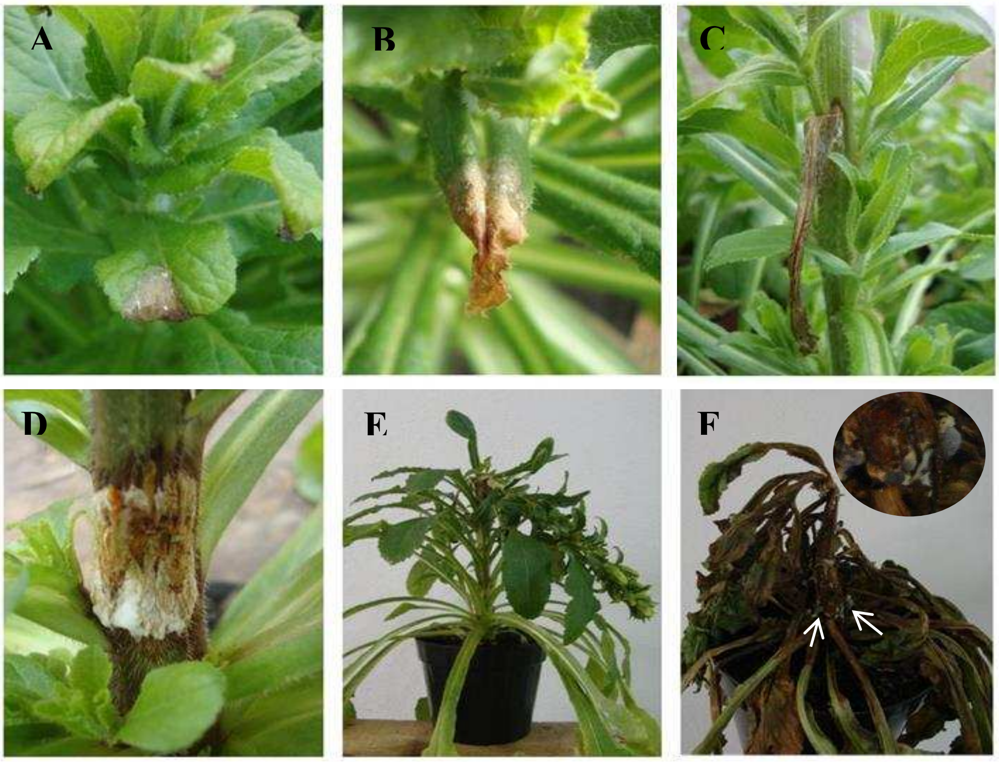


Figure 2. Symptoms of *Sclerotinia sclerotiorum* on *Campanula medium*. Attack starting on necrotic edge of leaf area (A), *S. sclerotiorum* expanding the leaf (B), initial attack of flower stem (C), micelle formation on flower stem (D), damping-off of flower stem (E), death of plant (F). Arrows indicate the sclerotia.

After inoculation, the fungus developed along the leaf, from apex to petiole, preferably over the vascular bundles, typically usually through the soft brown color (Figure 2B). The most severe damage occurs after the fungi infect the flower stem, for this he advances by vascular bundles until the insertion with flower stem (Figure 2C). In the stem, the pathogen evolves both towards the apex and the base can be observed initially chlorotic spots softened that expanded quickly to annealing stem (Figure 2D). This injury has evolved with the growth of fungus that grew mycelial with white cotton aspect about the injury that caused late wilting of plant. The attack caused floral stem rot, damping-off and loss of quality ornamental plants (Figure 2E). In plants completely attacked necrotic and softened tissue was observed in almost all plant. The development of mycelium and presence of sclerotia structures which are characteristic of this disease resistance also was observed (Figure 2F).

There are no products registered to control *S. sclerotiorum* in campanulas, so as general management is recommended, before the start of the cultivation, the analyzing the historic of production area and avoid using areas previously infected, get certified seedlings, plant fertilize balanced, dispose of crop residues and rotate culture.

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