Production of *Antirrhinum majus* seedlings on different substrates and containers

**Produção de mudas de *Antirrhinum majus* em diferentes substratos e recipientes**

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**Abstract**

The aim of this study was to determine the effects of type of substrate and expanded polystyrene trays on the production of snapdragon seedlings. The experiment was completely randomized with a 3 x 2 factorial design (substrates x number of tray cells) and four replications. ‘Baixa Sortida’ snapdragon seeds, commercial substrate A (rice husk + vermiculite), commercial substrate B (Sphagnum + torrefied rice straw + perlite), A + B mixture (1:1) and expanded polystyrene trays with 72 and 128 cells were used. The characteristics evaluated were plant emergence rate, percentage of plant emergence at 14, 21, 28 and 35 days, number of leaves at 44 and 58 days after sowing, shoot height, root length and plant dry matter. The results showed that the substrates directly influenced the production of snapdragon seedlings. Seedling emergence and seedling development is favored by the mixture of the substrates A and B (1:1) as well as by the use of expanded polystyrene trays with 72 cells due to the higher volume available to the seedling.

**Additional keywords:** floriculture; snapdragon; trays.

**Resumo**

O objetivo deste trabalho foi verificar o efeito do tipo de substrato e de bandejas de poliestireno expandido para a produção de mudas de boca-de-leão. O experimento foi realizado em delineamento inteiramente casualizado, em esquema fatorial 3x2 (substratos x número de células de bandejas), com quatro repetições. Foram utilizadas sementes de Boca-de-leão Baixa Sortida, substrato comercial A (casca de arroz + vermiculita), substrato comercial B (Esfagno + Palha de arroz Torrefada + Perilita) e a mistura A + B (1:1) e bandejas de poliestireno expandido de 72 e 128 células. As características avaliadas foram: velocidade de emergência de plantas, porcentagem de emergência de plantas aos 14, 21, 28 e 35 dias, número de folhas aos 44 e 58 dias após a semeadura, altura de parte aérea, comprimento de raiz e massa seca de planta. Os resultados obtidos permitiram concluir que os substratos utilizados influenciaram diretamente na produção de mudas de boca-de-leão: a emergência de plântulas e o desenvolvimento das mudas é favorecido pelo uso da mistura dos substratos A e B (1:1), assim como pelo uso de bandejas de poliestireno expandido de 72 células pelo maior volume disponível para a plântula.

**Palavras-chave adicionais:** bandejas; boca-de-leão; floricultura.

**Introduction**

The species *Antirrhinum majus* L., which belongs to the family Plantaginaceae (Lorenzi, 2013), is popularly known as snapdragon. It is appreciated because of its great diversity of petal colorings and its fragrance. It is among the cut flowers most produced in Brazil (Lima Junior et al., 2015).

The spread of this species occurs mostly by seeds. However, seeds are small and usually have a low germination potential. Thus, the production of seedlings in trays may optimize the initial production stage. A proper use of substrates is an important factor. According to Kämpf (2000), a substrate can be defined as a medium in which plant roots grow when not grown in the soil. Its main function is to support the plant and regulate the availability of water and nutrients.

The use of substrates for the production of seedlings aims to obtain high-quality plants in a short period with a low cost (Cunha et al., 2006). Compared to the cultivation in soils, there are some advantages of using substrates. They provide nutrients at more appropriate levels and times, reduce the risk of root environment salinization, and enable a more appropriate water handling, minimizing the occurrence of plant health problems which influence directly the yield and the quality of the final product.
Some materials such as sand, soil, peat, vermiculite, perlite and carbonized rice husk are used in the production of substrates by producers of ornamental plants. However, there are other options, such as coconut shell fiber (Takane et al., 2013). According to Aragão et al. (2011), the materials most used in the formulation of substrates are rice husk, tree barks, vermiculite, coconut fiber, earthworm humus, organic compost and common soil, among others.

Ludwig et al. (2015) found that growth and the distribution of dry mass and nitrogen in gerbera plants grown in pots are influenced by the physical and chemical characteristics of the substrates. Regarding snapdragon plants, Steffen et al. (2010) found that combinations of carbonized rice husk and earthworm humus can be efficient substrates for seedling production, since they provided favorable conditions for the growth of seedlings, especially high fertility. Associated with physical properties, they provided a satisfactory growth of snapdragon seedlings. However, information regarding the effects of commercial substrates available in the market for ready use by florists on the production of snapdragon seedlings is scarce.

Another important aspect is the type and size of the container for seedling production. These aspects markedly influence root and shoot growth. When seedlings are grown in small containers, the development of roots is restricted, causing stress (Di Benedetto & Pagani, 2013). Root restriction is hypothesized as a process that reduces the supply of assimilates to the shoots due to the decrease in root and leaf growth, leaf area and root volume (Di Benedetto, 2011), as well as changes in the partition of dry matter and nutrient absorption (Bar-Tal & Pressman, 1996; Dubik et al., 1990) and hormone metabolism (Peterson et al., 1991).

The effects of root growth restriction due to container size remains active for several weeks after transplanting until the new root system develops and adventitious roots appear (Di Benedetto & Pagani, 2013). In the production of Zinnia elegans seedlings in trays with 126 cells, there was an increased seedling development, with a greater height, shoot dry matter and percentage of survival (Sousa et al., 2011).

In addition, the container size used in seedling production directly affects the final cost. The amount of substrate to be used, the space the seedling will occupy in the greenhouse, the hand labor required for transportation, transfers for acclimatization and delivery to the producer are affected by container size. It also influences the amount of supplies that will be required (Queiroz & Melém Jr., 2001).

However, information related to the type of trays for the production of seedlings of ornamental species is scarce. Thus, the aim of this study was to determine the effects of type of substrate and expanded polystyrene trays on the production of snapdragon seedlings.

### Material and methods

The experiment was conducted from April to June 2015 in a greenhouse at the experimental teaching area of the Federal University of Pampa, campus Ilhaqui, located at 29º12’28” S and 56º18’28” W. The experiment was completely randomized with a 3 x 2 factorial design (substrates x number of tray cells) and four replicates. 'Baixa Sortida' snapdragon seeds, category S2, with a germination rate of 89% (indicated by the manufacturer) were used. The substrates used were A (Mecplant®), B (Carolina Padrão®) and the mixture A + B (Mecplant® + Carolina Padrão® at 1:1). The characteristics of the substrates, according to the manufacturers, are shown in Table 1.

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Composition</th>
<th>WRC (%)</th>
<th>CEC (mmol dm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Mecplant®)</td>
<td>Pine bark, Vermiculite, Sphagnum</td>
<td>60</td>
<td>200</td>
</tr>
<tr>
<td>B (Carolina Padrão®)</td>
<td>Torrefied rice straw, Perlite</td>
<td>51</td>
<td>1200</td>
</tr>
</tbody>
</table>

The seeds were sown in polystyrene trays with 72 and 128 cells containing the substrates A, B and the mixture A + B (1:1). The sowing was carried out by planting one seed per cell, 1 cm deep, covered with a thin layer of substrate. The trays were placed on benches in a greenhouse without control of temperature and humidity and covered with plastic forming a low tunnel, which was opened and closed every day at the beginning and in late afternoon, respectively. Daily irrigations were performed so as to always keep the substrates wet aiming the correct development of the seedlings. The water volume was equivalent to 60% of the retention capacity of each treatment.

The characteristics evaluated were plant emergence speed, percentage of plant emergence at 14, 21, 28 and 35 days, number of leaves, shoot height, root length and plant dry matter. To obtain emergence speed, daily counts were made of the number of emerged seedlings. Later, the resulting values were used for calculation based on the formula proposed by Maguire (1962). Seedling emergence percentage: at 14, 21, 28 and 35 days, evaluations were carried out accounting for the number of emerged plants. The counting of number of leaves was per-
formed at 44 and 58 days after sowing from 20 plants selected at random from each plot. Shoot height and root length were measured 58 days after sowing with a graduated ruler. The results were expressed in cm. Plant dry matter: after evaluation of seedling height, seedlings were placed in paper bags and taken to a forced-air circulation oven at 65 °C for 72 hours. Then, they were weighted with a precision balance (0.001 g). The weight values were divided by 20, expressing the dry matter results as g plant¹. The results were submitted to analysis of variance and mean comparison by Scott Knott test (p<0.05).

Results and discussions

The emergence of plants at 14 and 35 days after sowing (DAS) was influenced by substrate and number of tray cells (Table 2). At 14 DAS, in trays with 72 cells, the substrate mixture (1:1) provided the best performance (Table 2). The substrate B, when used alone, did not result in a good seedling emergence, with a percentage lower than 10%. However, when it was used in trays with 128 cells, the emergence was nearly four times higher, reaching 36% (Table 2). Thus, it is observed that, besides the effects of the composition of the substrate, the container volume directly affects seedlings emergence.

Table 2 - Mean values of seedling emergence at 14 (SE14) and 35 (SE35) days after sowing of 'Baixa Sortida' snapdragon seeds produced in different substrates and trays with a different number of cells.

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Number of cells</th>
<th>SE14 (%)</th>
<th>SE35 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>72</td>
<td>32 bA</td>
<td>77 aA</td>
</tr>
<tr>
<td>B</td>
<td>72</td>
<td>8 cB</td>
<td>83 aA</td>
</tr>
<tr>
<td>A + B</td>
<td>128</td>
<td>79 aA</td>
<td>62 bB</td>
</tr>
<tr>
<td>CV (%)</td>
<td>34.8</td>
<td>7.0</td>
<td>25.4</td>
</tr>
</tbody>
</table>

*Means followed by the same lowercase letter in columns and upper case letter in rows do not differ by Scott-Knott test (p > 0.05).

At 14 DAS, the mixture of the substrates A and B in trays with 72 cells and the substrate A in a tray at 128 trays resulted in 79 and 55% of emerged seedlings, respectively. These results indicate the efficiency of these substrates. According to Greel (2007), the production of snapdragon seedlings occurs in three phases: in phase I (4-8 DAS), there is the emission of the primary root; during phases II (7-14 DAS) and III (14-21 DAS), the initial seedling development occurs; subsequently, up to approximately 35 DAS, seedlings reach an optimal size for transplantation.

Most of the published literature reports that the larger the container the better the development of seedlings (Antoniazzi et al., 2013; Oh et al., 2014; Oagile et al., 2016). However, this research found that the initial development, depending on the composition of the substrate, may be favored at lower cell volumes. Considering that the seeds of this species are small (7,680 seeds per gram), it is possible that, in a tray with smaller cells, seeds were more exposed to the water available in the substrate, which resulted in a greater speed of imbibition, germination, and, consequently, seedling emergence.

According to Carvalho & Nakagawa (2012), the larger the contact area between the soil and the seed coating, the faster the water absorption. By the results of emergence speed analyses (Table 2), it is possible to confirm this hypothesis, since there was a faster emergence in trays with 128 cells containing the substrates A and B.

Regarding the emergence of seedlings at 35 DAS, the substrates A and B, when used separately, were more efficient in trays with 72 cells compared to the mixture (A + B). In trays with 128 cells, only the substrate B, or the mixture with A, was more efficient regarding seedling emergence (Table 2).

Seedling emergence rate was higher when using the substrate A in trays with 128 cells, as well as the mixture with B in trays with 72 cells (Table 3). The decrease in emergence speed by using the substrate B alone is possibly related to its lower water retention capacity, thus making less water available for germination and seedling development. A higher emergence speed could favor the production of seedlings, as it results in less time for the completion of this step, consequently resulting in lower costs for the producer and in more efficiency of the production system.

Table 3 - Mean values of seedling emergence speed (SES) of 'Baixa Sortida' snapdragon seeds produced in different substrates and trays with a different number of cells.

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Number of cells</th>
<th>SES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>72</td>
<td>110 bB</td>
</tr>
<tr>
<td>B</td>
<td>72</td>
<td>62 bB</td>
</tr>
<tr>
<td>A + B</td>
<td>128</td>
<td>184 aA</td>
</tr>
<tr>
<td>CV (%)</td>
<td>25.4</td>
<td></td>
</tr>
</tbody>
</table>

*Means followed by the same lowercase letter in columns and upper case letter in rows do not differ by Scott-Knott test (p>0.05).

Considering the evaluations at 21 and 28 DAS, there was no interaction between the factors substrate and cell number. There were differences only in relation to substrate (Table 4). There was a similar
response and better results by using only A or a mixture with B. Water retention capacity characteristics and the CEC of the substrates possibly interfered with the growth and development of seedlings, influencing seedling emergence. According to Schmitz et al. (2002), cation exchange capacity (CEC), among others, is one of the main chemical properties considered in the characterization of substrates. It is possible to observe in Table 1 a great difference in the CEC of the substrates.

Table 4 - Mean values of seedling emergence at 21 (SE21) and 28 (SE28) days after sowing of ‘Baixa Sortida’ snapdragon seedlings produced using different substrates.

<table>
<thead>
<tr>
<th>Substrate</th>
<th>SE 21 DAS (%)</th>
<th>SE 28 DAS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>68 a</td>
<td>77 a</td>
</tr>
<tr>
<td>B</td>
<td>41 b</td>
<td>58 b</td>
</tr>
<tr>
<td>A + B</td>
<td>79 a</td>
<td>80 a</td>
</tr>
<tr>
<td>CV (%)</td>
<td>18.9</td>
<td>6.4</td>
</tr>
</tbody>
</table>

*Means followed by the same lowercase letter in columns do not differ by Scott-Knott test (p>0.05).

According to Ronquim (2010), CEC is the graduation of the release capacity of several nutrients, favoring fertility for a longer period. However, in this case, it is possible that the high CEC of the substrate B prevented the release of nutrients in the short term (35 days), resulting in a lower seedling development.

Regarding the size of seedlings, it was found that the mixture of the substrates A and B presented a higher growth, both in shoots and roots, when trays with 72 cells were used (Table 5). In trays with 128 cells, there was no difference between the substrates. In relation to tray size, using only the mixture of substrates, there was less development of seedling roots and shoots in trays with 128 cells.

Mendonça et al. (2003) argue that containers with a higher volume provide a better growth of the root system of seedlings. Sousa et al. (2011) found that the use of trays with 126 cells was more efficient when compared with trays with 150 and 228 cells for the production of Zinnia spp. seedlings. The superiority of containers with a higher volume regarding plant development is directly related to their intrinsic characteristics, such as height and volumetric capacity. This results in a greater area to support roots and therefore in more nutrients, besides an improvement in some physical characteristics such as aeration space (Bomfim, 2006). A good development of the root system is essential to the success of the transplant because plants need well-formed roots to be fixed to the soil and to absorb water and nutrients.

In turn, the accumulation of biomass in seedlings was favored by the mixture of substrates in trays with 72 cells and by the substrate A in trays with 128 cells. In *Impatiens walleriana*, the shoot biomass of the seedling is related to root dry matter. The greater the volume of the cell tray, the higher the growth rate (Di Benedetto & Pagani, 2013). Riaz et al. (2008) found that the use of combinations of substrates favorably affected the growth of Zinnia spp. seedlings.

The number of seedling leaves was influenced by the type of substrate and by trays. There was a better performance by using the mixture of substrates in trays with 72 cells 44 days after sowing, or by using only the substrate A and the mixture thereof with B in trays with 72 cells 58 days after sowing (Table 5).

In the literature, there are discussions regarding the ideal conditions for transplant, ranging from 2-3 (Creel, 2007) to 4-5 leaves (Hanks, 2014). However, both studies report periods of four to five weeks for the formation of seedlings at temperatures ranging from 18 to 24°C (Creel, 2007; Hanks, 2014). The production of seedlings in this study was conducted in the fall, in southern Brazil, a place with an average temperature of 19°C during that period (data from the Weather Station at the University campus), which is consistent with common recommendations. However, there was no effective control of temperature. Variations may have occurred during this period.

Table 5 - Mean values for seedling height (SH), root length (RL), plant dry matter (PDM) and number of leaves at 44 (NL1) and 58 (NL2) days after sowing of ‘Baixa Sortida’ snapdragon seedlings produced in different substrates and trays with different number of cells.

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Number of cells</th>
<th>SH (cm)</th>
<th>72</th>
<th>128</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>9.9 aA</td>
<td>4.4 aA</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>6.8 aA</td>
<td>6.9 aA</td>
<td></td>
</tr>
<tr>
<td>A + B</td>
<td></td>
<td>15.4 aA</td>
<td>8.0 aA</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td>20.4</td>
<td>10.4</td>
<td>18.5</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>8.3 aA</td>
<td>7.1 aA</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>6.7 aA</td>
<td>6.9 aA</td>
<td></td>
</tr>
<tr>
<td>A + B</td>
<td></td>
<td>10.9 aA</td>
<td>6.9 aA</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td>20.4</td>
<td>11.4</td>
<td>20.4</td>
</tr>
</tbody>
</table>

*Means followed by the same lowercase letter in columns and upper case letter in rows do not differ by Scott-Knott test (p>0.05).
It is important to mention that previously, at 44 DAS, there already were plants containing the number of leaves needed for transplantation in all treatments. However, at that time, the root system of the plants was not fully developed (data not shown), as was found in a sampling by a visual analysis of the seedlings at 35 DAS. Therefore, the evaluation was conducted at 44 and 58 DAS.

The precocity in obtaining the size of seedlings and the number of leaves ideal for transplantation is critical for a production system. The use of substrates that shorten the period that plants remain in trays becomes an important tool for production, as this means the possibility of more production cycles in the greenhouse, reduced costs and increased working capital to the producer (Freitas et al., 2013).

**Conclusions**

The substrates directly influenced the production of snapdragon seedlings. Seedling emergence and seedling development was favored by the mixture of substrates (MecPlant®, based on pine shells and rice husks), by the substrate B (Carolina Standard®, based on sphagnum, torrefied rice straw and pearl at 1:1), and by the use of expanded polystyrene trays with 72 cells due to the larger volume available for the seedling.

**References**


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