

## Emergence and development of *Dianthus chinensis* and *Limonium sinuatum* seedlings on commercial substrate

Emergência e desenvolvimento de mudas de *Dianthus chinensis* e *Limonium sinuatum* em substratos comerciais

Emergencia y desarrollo de plántulas de *Dianthus chinensis* y *Limonium sinuatum* en sustratos comerciales

Received: 08/06/2021 | Reviewed: 08/13/2021 | Accept: 08/18/2021 | Published: 08/21/2021

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### Abstract

*Limonium sinuatum* and *Dianthus chinensis* are plant species of great importance in Brazilian floriculture, being propagated by seed, therefore, the characteristics of the substrates used are respectable in seedlings emergence and development process. Thus, the objective of this research was to evaluate the influence of two commercial substrates on emergence and development of *Limonium sinuatum* and *Dianthus chinensis* seedlings. The experiment was conducted in a greenhouse (Pad & Fan type) at São Paulo State University. The treatments were: T1 – Basaplant<sup>®</sup> and T2 – Tropstrato<sup>®</sup>, for both species, whose seeds were germinated in expanded polystyrene trays of 128 cells, being eight replicates, containing 8 seeds/replicate. The evaluated traits were: percentage of emergence, emergence speed index, mean emergence time, shoot height, root length and seedlings fresh and dry mass. The substrate characteristics evaluated were: pH, electrical conductivity, macroporosity, microporosity, total porosity, density and water retention capacity. The experimental design was completely randomized, and data were submitted to analysis of variance to Tukey test at 5% to compare the means. The emergence of *Limonium sinuatum* and *Dianthus chinensis* were impaired, possibly due to low electrical conductivity provided by substrates. However, Basaplant<sup>®</sup> substrate favoured the development of evaluated species in relation to aerial part length, root length and total fresh and dry mass, which is recommended for using as substrate for both species.

**Keywords:** Floriculture; Ornamental plants propagation; Basaplant<sup>®</sup>; Tropstrato<sup>®</sup>.

### Resumo

*Limonium sinuatum* e *Dianthus chinensis* são espécies vegetais de grande importância na floricultura brasileira, sendo propagadas por sementes, portanto, as características dos substratos utilizados são respeitáveis no processo de emergência e desenvolvimento de mudas. Assim, o objetivo desta pesquisa foi avaliar a influência de dois substratos comerciais na emergência e no desenvolvimento de mudas de *Limonium sinuatum* e *Dianthus chinensis*. O experimento foi conduzido em casa de vegetação (tipo Pad & Fan) da Universidade Estadual Paulista. Os tratamentos foram: T1 - Basaplant<sup>®</sup> e T2 - Tropstrato<sup>®</sup>, para ambas as espécies, cujas sementes foram germinadas em bandejas de poliestireno expandido de 128 células, sendo oito repetições, contendo 8 sementes/repetição. As características

avaliadas foram: porcentagem de emergência, índice de velocidade de emergência, tempo médio de emergência, altura da parte aérea, comprimento da raiz e massa fresca e seca das mudas. As características do substrato avaliadas foram: pH, condutividade elétrica, macroporosidade, microporosidade, porosidade total, densidade e capacidade de retenção de água. O delineamento experimental foi inteiramente casualizado, e os dados foram submetidos à análise de variância ao teste de Tukey a 5% para comparação das médias. A emergência de *Limonium sinuatum* e *Dianthus chinensis* foi prejudicada, possivelmente devido à baixa condutividade elétrica fornecida pelos substratos. Entretanto, o substrato Basaplant® favoreceu o desenvolvimento das espécies estudadas em relação ao comprimento de parte aérea, comprimento de raiz e massa fresca e seca total, o que é recomendado para uso como substrato para ambas espécies.

**Palavras-chave:** Floricultura; Propagação de plantas ornamentais; Basaplant®; Tropstrato®.

### Resumen

*Limonium sinuatum* y *Dianthus chinensis* son especies vegetales de gran importancia en la floricultura brasileña, siendo propagadas por semilla, por lo que las características de los sustratos utilizados son respetables en el proceso de emergencia y desarrollo de las plántulas. Así, el objetivo de esta investigación fue evaluar la influencia de los sustratos comerciales en la emergencia y desarrollo de plántulas de *Limonium sinuatum* y *Dianthus chinensis*. El experimento se realizó en un invernadero (tipo Pad & Fan) de la Universidad Estadual de São Paulo. Los tratamientos fueron: T1 - Basaplant® y T2 - Tropstrato®, para ambas especies, cuyas semillas fueron germinadas en bandejas de poliestireno expandido de 128 células, siendo ocho réplicas, conteniendo 8 semillas/réplica. Los rasgos evaluados fueron: porcentaje de emergencia, índice de velocidad de emergencia, tiempo medio de emergencia, altura de brote, longitud de raíz y masa fresca y seca de plántulas. Las características del sustrato evaluadas fueron: pH, conductividad eléctrica, macroporosidad, microporosidad, porosidad total, densidad y capacidad de retención de agua. El diseño experimental fue completamente al azar, y los datos se sometieron a análisis de varianza a la prueba de Tukey al 5% para comparar las medias. La emergencia de *Limonium sinuatum* y *Dianthus chinensis* se vio afectada, posiblemente debido a la baja conductividad eléctrica proporcionada por los sustratos. Sin embargo, el sustrato Basaplant® favoreció el desarrollo de las especies estudiadas en relación a longitud de brote, longitud de raíz y masa total fresca y seca, lo que se recomienda para su uso como sustrato para ambas especies.

**Palabras clave:** Floricultura; Propagación de plantas ornamentales; Basaplant®; Tropstrato®.

## 1. Introduction

The consumption of ornamental plants in Brazil has increased over the past few years, as the country had revenues of R\$ 6.6 billion (US\$ 1,3 billion) in 2016, and for the year 2017, the prediction is to increase 9%, reaching around R\$ 7.2 billion (US\$ 1,4 billion) (Instituto Brasileiro de Floricultura - Ibraflor, 2017). With this growth, cut flowers highlight, for the composition of floral arrangements and seedlings production, which may be used for many purposes, such as landscape compositions or own cultivation (Junqueira and Peetz, 2017), being genus *Limonium* and *Dianthus* of great importance in flower market as they are widely cultivated (Junqueira and Peetz, 2008).

*Limonium sinuatum* belongs to the Plumbaginaceae family, is popularly known as Estátice (In Brazilian Portuguese) and is commercialized as a cut flower for composition, mainly, in floral arrangements (Ciotta and Nunes, 2011). On the other hand, *Dianthus chinensis* (Caryophyllaceae family), commonly called Cravina in Brazil, is a perennial herbaceous species, which may also be used both as a cutting flower and in gardens composition (Lopes et al. 2016). According to Lorenzi (2015), both are Mediterranean and thus considered halophytes (tolerant to saline soils), being used both in the restoration of saline environments and in urban landscaping (Sánchez, 2011).

Both species described are propagated mainly by seeds (Lorenzi, 2015), however, their production must be performed on suitable substrates (Pirola et al. 2015), to ensure the success in first floral bud opening and market consumer reaching, phase in which the plant draws more attention for its colour and perfume (Junqueira and Peetz, 2017).

Choosing the ideal substrate for each plant species is fundamental, as it is the beginning of a whole production chain that starts from seedling production, plant development and finish with sale, either as cutting plant or as pot plant. Moreover, for seedling productions, substrates have their global use by offering improved physical, chemical and biological development of plants (Kämpf, 2001; Pagliarini et al. 2019).

According to Santos and Castilho (2018) and Maldaner et al. (2019), an ideal substrate for ornamental species must present good conditions of aeration, pH, electrical conductivity, water retention capacity, nutritional availability, and density, in order to result in lower expenses and, consequently, increase healthy seedlings sale (Santos et al. 2019).

According to Fernandes and Corá (2001) and Moreira et al. (2017), the use of specific substrates, with certain characteristics directed to the crop that will be produced promotes improvements in plant development, reduced cultivation time and final product cost.

Therefore, the objective was to evaluate the influence of commercial substrates on emergence and development of *Limonium sinuatum* and *Dianthus chinensis* seedlings.

## 2. Methodology

The experiment was performed at the School of Engineering of São Paulo State University (UNESP), Campus of Ilha Solteira, São Paulo state, Brazil, in a greenhouse Pad & Fan type, which presented an average ambient temperature of 28.9 °C and a relative humidity of 78.4%.

The seeds of *L. sinuatum* and *D. chinensis* were donated by the Topseed® company and sown in 128 cell expanded polystyrene trays, filled with two different commercial substrates: T1 - Tropstrato® (pine bark + coconut fibre + fibrous peat + vermiculite) and T2 - Basaplant® (pine bark + peat + expanded vermiculite).

The evaluations performed were: percentage of emergence (%E), counting the number of emerged seeds with the emission of hypocotyl, according to procedure proposed by Brasil (1999); emergence speed index (ESI), according to methodology proposed by Maguire (1962) and mean emergence time (MET), according to Labouriau (1983). To calculate the ESI and MET, daily counts of seedlings emerged for 21 and 14 days, respectively, for *L. sinuatum* and *D. chinensis*. The percentage of emergence was calculated at the end of each cycle depending on the species as mentioned previously.

At the end of emergence counting biometric evaluations of seedlings were performed: aerial part length (APL), which was determined measuring using a graduated ruler from the surface of substrate to the seedling apex; root length (RL), measuring also with a graduated ruler, from the point where aerial part length was measured (close to the substrate) to the apex of the main root.

In addition, total fresh mass (TFM) was evaluated, performed by weighing all emerged seedlings in each plot; after this step, the same seedlings were packed in properly identified kraft paper bags and placed to dry in a forced air circulation oven at 65 °C for 72 hours until reaching constant mass, then they were removed, weighed again to find the total dry mass (TDM). Both masses were weighed on a 0.01 g precision analytical balance.

The substrates chemical characteristics evaluated were: pH, using the pHmeter pHTestr2 and electrical conductivity (EC – dS m<sup>-1</sup>), using TDSTestr4 conductivity meter, in two different time: before and after experiment implementation. To determine these characteristics an 1:2 dilution of substrate and distilled water was used, according to methodology described by Kämpf (2005).

In relation to physical characteristics were evaluated macroporosity, microporosity, total porosity, water retention capacity and density, using the methodologies proposed by Teixeira et al. (2017), with samples collected at the time of experiment installation.

The experimental design used was completely randomized, being for each species: two treatments and eight replication, containing eight seeds per plot. The results were submitted to analysis of variance and means compared by Tukey test at 5% probability level, using the SISVAR program (Ferreira, 2019).

### 3. Results and Discussion

Table 1 shows the pH and electrical conductivity (EC) values determined for the different substrates in two different time: before sowing and at the end of experiment.

**Table 1.** Values of pH and electrical conductivity (EC – dS m<sup>-1</sup>) of Basaplant<sup>®</sup> and Tropstrato<sup>®</sup> substrates in different evaluated times: after sowing (AS).

Substrate	Before sowing		At the end of experiment			
	pH	EC (dS m <sup>-1</sup> )	<i>Limonium sinuatum</i>		<i>Dianthus chinensis</i>	
			pH	EC (dS m <sup>-1</sup> )	pH	EC (dS m <sup>-1</sup> )
Basaplant <sup>®</sup>	6.0	0.4	5.9	0.2	5.4	0.3
Tropstrato <sup>®</sup>	5.8	0.3	5.5	0.3	5.6	0.4

Source: The authors.

It was possible to observe in Table 1 that, before sowing, the pH values in Basaplant<sup>®</sup> were 6.0 and in Topstrato<sup>®</sup> 5.8, which corroborate to information provided by manufacturers that specified at package the pH of Basaplant<sup>®</sup> varied around 5.8 ± 0.5 and Tropstrato<sup>®</sup> varied around 5.8 ± 0.3.

According to Kämpf (2005), the substrate pH range considered optimal for seedlings development is between 5.2 and 5.5 meaning that before experiments installation, the values observed were above recommended (Table 1). However, for the *Dianthus chinensis*, the ideal pH, according to Larson (1992), is between 5.5 and 6.0, whereas for *Limonium sinuatum*, is around 5.0 to 6.0 according to Ball (2016), thus the values observed in Table 1 are within the recommended range.

At the end of experiment there was pH reduction for both substrates; Basaplant<sup>®</sup> and Tropstrato<sup>®</sup> reduced 0.1 and 0.3 in *L. sinuatum* cultivation and 0.6 and 0.2 in *D. chinensis*, respectively. Even with the pH reduction, the ranges obtained are still within the recommendations by authors mentioned previously. The reasons that may have triggered the pH variations are related to some factors, such as the irrigation water in the substrate solution and the influence of plant species during cultivation (Brito, 2015). According to Silveira Junior et al. (2012) water may change the pH with a slight increase in it, as it is generally alkaline, which in long term may change the value. However, this fact did not corroborate to the present work, due to the decreased values, so it may be deduced that the most incisive factor was the interaction between species and substrates.

The EC found in substrates was reduced after ending the experiment for *L. sinuatum* (Table 1). In *L. sinuatum* and *D. chinensis* crops it varied from 0.2-0.3 and 0.3-0.4 dS m<sup>-1</sup> in Basaplant<sup>®</sup> and Tropstrato<sup>®</sup>, respectively. According to Ball (2016), *L. sinuatum* ideal EC is 1.4 dS m<sup>-1</sup>, which is higher than found in this work. For *D. chinensis*, in the other hand, the ideal EC is from 4.0 dS m<sup>-1</sup> to 5.0 dS m<sup>-1</sup> (Grieve et al. 2012), which are also higher than the obtained values. However, these ranges suggested by the authors are because the species are from Mediterranean climate, meaning more adaptation to saline soils, which present high EC (Sánchez, 2011). Thus, it is inferred that their development may have been harmed, as they need higher EC values for the conditions to be considered ideal.

However, Takii (2015) recommends EC for *D. chinensis* around 0.5 to 0.75 dS m<sup>-1</sup> during the emergence stage for cotyledon expansion; 0.75 dS m<sup>-1</sup> from cotyledon expansion until true leaf growth and 0.75 to 1.0 dS m<sup>-1</sup> until seedling formation, values higher than those obtained in the current research.

Tropstrato<sup>®</sup> substrate increased the EC by 0.1 dS m<sup>-1</sup> for the *D. chinensis* at the end of experiment (Table 1). This elevation, even being small, may change plants metabolism, interfering at water and nutrients absorption and relating to several factors, such as stomatal opening and closing and increase or reduction in leaf area (Beltrão et al. 1997; Taiz and Zeiger, 2017).

At the same evaluation, the EC reduction at Basaplant® substrate in 0.2 and 0.1 dS m<sup>-1</sup> for *L. sinuatum* and *D. chinensis*, respectively, is due to, according to Boaro (2013), the ions leaching in the substrate caused by irrigation.

Among analysed substrates, both presented EC within the range provided by the manufacturers. According to them, Tropstrato® presents EC of 0.2 ± 0.3 dS m<sup>-1</sup> which, according to Cavins et al. (2000), corresponds to adequate salinity for the development of most crops (0.26 dS m<sup>-1</sup> to 0.75 dS m<sup>-1</sup>). The same may be observed in Basaplant® substrate, with EC provided between 0.25 ± 0.03 dS m<sup>-1</sup>, partially fitting within the range considered ideal.

Table 2 shows macroporosity (%), microporosity (%), total porosity (%), density (g cm<sup>-3</sup>) and water holding capacity (cm<sup>3</sup> cm<sup>-3</sup>) values for both evaluated substrates.

**Table 2.** Macroporosity (MA – %), Microporosity (MI – %), Total Porosity (TP – %), Density (DE – g cm<sup>-3</sup>) and Water Retention Capacity (WRC – cm<sup>3</sup> cm<sup>-3</sup>) for the evaluated commercial substrates Basaplant® and Tropstrato®.

Substrate	MA (%)	MI (%)	TP (%)	DE (g cm <sup>-3</sup> )	WRC (cm <sup>3</sup> cm <sup>-3</sup> )
Basaplant®	34.20a	34.13a	68.33a	0.36a	0.64b
Tropstrato®	31.40a	41.47a	72.90a	0.31a	0.71a
CV%	9.18	6.58	7.75	7.31	5,54

Means followed by the same letter, in the columns, do not differ significantly from each other by Tukey test at 5% probability.  
 Source: The authors.

According to analyses, Basaplant® substrate did not differ statistically from Tropstrato® in terms of macroporosity, microporosity, total porosity and density traits (Table 2). Working with commercial substrate, Araújo (2010) found macroporosity of 10.8%, microporosity of 62.92%, total porosity of 73.72% and density of 0.28 g cm<sup>-3</sup>, comparing to the results obtained with the present study, only total porosity of Tropstrato® is close to mention by the author. For the other results, macroporosity and density are above and microporosity below.

Kämpf (2005) reported that the ideal substrate is the one that offers greater porosity, as in addition to making better water filtration, it facilitates root growth, as it becomes the way in which the roots develop outside the soil, in addition to that, for Vifinex (2002), the total porosity must be greater than 50%, a number reached by two substrates (Table 2), however, Kämpf (2001) proposed values between 75% to 90%, higher than found in the research (Table 2).

Santos and Castilho (2016) recommend for plant development, substrates containing 17% of macropores, 40% of micropores and a density of 0.99 g cm<sup>-3</sup>, however, in the present work only microporosity in Tropstrato® presented value close to mentioned.

Density, according to Kämpf (2005), comprises an ideal range of 0.1 and 0.3 g cm<sup>-3</sup> for cultivation in multicellular trays, on the other hand, Vifinex (2002) reported that the optimal recommended density value for most plants ranges from 0.3 g cm<sup>-3</sup> to 0.4 g cm<sup>-3</sup> within the range obtained in this study of 0.36 g cm<sup>-3</sup> and 0.31 g cm<sup>-3</sup> for Basaplant® and Tropstrato®, respectively (Table 2).

In studies with ornamental species, Araújo (2010) found that the commercial substrate presented good density (0.29 g cm<sup>-3</sup>) compared to 10 formulations of substrate components, value lower than those found in the present work (Table 2). It is also observed that the greater the porosity, the lower the substrate density, thus inferring that both are inversely proportional, a fact that was also confirmed by Fernandes and Corá (2004), in commercial substrates, and Santos and Castilho (2016) in physical analysis of substrates for plant development.

Regarding substrates water retention capacity, it is noted that this was the only physical attribute to present statistical difference, where Tropstrato® showed the best result (Table 2). This is due to this treatment presented high total porosity and low density, therefore the substrate responds better in water storage, despite not presenting statistical difference. However, the ideal value for water retention capacity according to Boertje (1984) is between 0.64 and 0.71 cm<sup>3</sup> cm<sup>-3</sup> and both substrates are within the recommended range.

In this way, understanding the dynamics of relationships between solids and pores is fundamental to achieving success in seedlings production (Lacerda et al. 2006), as cultivation in containers requires that substrate maintain water available to the plant without compromising its oxygen concentration (Fermino, 2002), and thus it is expected that Tropstrato® presents better germination and development responses of plant species, due to better physical attributes.

At Table 3 it is possible to note percentage of emergence (%E), emergence speed index (ESI) and mean emergence time (MET – days) data for *L. sinuatum* and *D. chinensis* cultivated in Basaplant® and Tropstrato® substrates.

**Table 3.** Percentage of emergence (%E), emergence speed index (ESI) and mean emergence time (MET – days) of *Limonium sinuatum* and *Dianthus chinensis* cultivated in Basaplant® and Tropstrato® substrates.

Substrate	<i>Limonium sinuatum</i>			<i>Dianthus chinensis</i>		
	%E	ESI	MET	%E	ESI	MET
Basaplant®	65.62a	1.21a	5.07a	50.00a	0.72a	5.89a
Tropstrato®	56.25a	1.02a	5.01a	51.56a	0.75a	5.64a
CV (%)	28.75	28.81	19.36	37.72	38.79	15.72

Means followed by the same letter, in the columns, do not differ significantly from each other by Tukey test at 5% probability.  
 Source: The authors.

It is noted in Table 3 that there were no statistical differences for any evaluated trait for both substrates within each species. *L. sinuatum* presented 65.62% and 56.25% of %E and *D. chinensis* 50.00% and 51.56%.

Papafotiou and Stragas (2007), working with *D. fruticosus* seeds, which belongs to the same genus as *D. chinensis*, found emergence of 97%, result bigger that found in the present work. Azizi et al. (2011) studying different salinity conditions for germination of *D. barbatus*, observed that the control treatment (without saline solution) presented 100% of seed germination, however, the treatments with salinity water also presented good results of seed germination reaching 75%. Nevertheless, at that research, pre-germinative treatments were performed on seeds, which was not done in the present study, which implies that the seeds might need some procedure before being put to germinate, but this information was not informed at seed package.

Working with different environments for *L. sinuatum* emergence, Ayala-Garay et al. (2011) found range of 72.1% to 95.5% of %E, results above those found in the present work. For the genus *Limonium*, Fernández et al. (2015), in *L. insigne*, observed that seed germination was influenced by temperature and salinity, reaching 97% in the control, and good responses also under salinity conditions, however the reported value does not corroborate with the present study.

It is supposed that the difference observed between the %E obtained in the work and the value expected for both species may have happened due to the influence of pH and electrical conductivity values (Table 1). However, considering that the pH values observed in the analysis were within the ranges recommended by Ball (2016) and Facts (2017) (5.0 to 6.0 and 5.8 to 6.2), it is deduced that the greatest influence may have been triggered by EC, which was different the ideal determinations of 1.4 dS m<sup>-1</sup> for *L. sinuatum* (Ball, 2016) and 4.0 dS m<sup>-1</sup> and 5.0 dS m<sup>-1</sup> for *D. chinensis* (Grieve et al. 2012),

indicating the need for higher saline contents to germinate properly, as both are Mediterranean climate species, and adapted to saline soils (Lorenzi, 2015).

Hassan et al. (2017) evaluating the germination of four different species of *Limonium* at NaCl concentrations, observed that seeds presented higher %E value when subjected to certain salinity concentrations, with values of 80% for *L. santapolense* (50 mM NaCl), 75% for *L. virgatum* (100 mM NaCl), 83% for *L. narbonense* (50 mM NaCl) and 68% for *L. girodianum*, corroborating to cited.

Rosa et al. (2015) stated that different levels of salinity may delay and reduce the number of germinated seeds, depending on the tolerance of each species. Thus, in the present work, the EC levels were below the recommended for the crop, which perhaps explains the difference between the expected and the verified %E.

Basaplant<sup>®</sup> was the substrate with the highest EC values (0.4 dS m<sup>-1</sup>) before sowing, however there was reduction of 0.2 dS m<sup>-1</sup>, at the end of experiment for *L. sinuatum*, which may have occurred according to Boaro (2013) by nutrients leaching during irrigation process, however this was the treatment that presented the highest %E.

The emergence speed index (ESI) is related to seed vigour. Plants that present high ESI are less vulnerable to adverse environmental conditions as they emerge faster, spending less time in the initial stages of development (Oliveira et al. 2009). However, it is observed that the values obtained from Table 3 of ESI did not differ statistically in any of treatments, presenting similar results.

Also, according to Rollwagen and Carvalho (2011), ESI and MET (mean emergency time) values are inversely proportional, when seed has higher germination speed, its mean emergence time decreases, a fact observed in the present study. There was no difference in MET values between substrates (ranging from 5.07 to 5.89 days. Nevertheless, the values found for *L. sinuatum* are below those observed by Santo et al. (2017) working with germination of *L. avei*, which found MET of 2.3 days. As for *D. chinensis*, the results corroborate the value of 5.83 days of MET in emergence with *D. morisianus* evidenced by Nebot et al., (2016), however the %E observed by the authors was 94%, while that obtained in the Table 3 is low.

Table 4 shows the aerial part length (APL – cm), root length (RL – cm), total fresh mass (TFM – g) and total dry mass (TDM – g) of *L. sinuatum* and *D. chinensis* cultivated in Basaplant<sup>®</sup> and Tropstrato<sup>®</sup> substrates.

**Table 4.** Aerial part length (APL – cm), root length (RL – cm), total fresh mass (TFM – g) and total dry mass (TDM – g) of *Limonium sinuatum* and *Dianthus chinensis* cultivated in Basaplant<sup>®</sup> and Tropstrato<sup>®</sup> substrates.

Substrate	APL (cm)	RL (cm)	TFM (g)	TDM (g)
<i>Limonium sinuatum</i>				
Basaplant <sup>®</sup>	5.86a	4.59a	0.76a	0.08a
Tropstrato <sup>®</sup>	2.4b	2.88a	0.14b	0.02b
CV (%)	11.14	17.85	15.13	17.64
<i>Dianthus chinensis</i>				
Basaplant <sup>®</sup>	4.59a	4.55a	0.38a	0.04a
Tropstrato <sup>®</sup>	1.59b	3.48a	0.10b	0.01b
CV (%)	37.00	38.17	22.99	23.92

Means followed by the same letter, in the columns, do not differ significantly from each other by Tukey test at 5% probability.  
 Source: the authors.

There were statistical differences between analysed substrates for some traits such as aerial part length, total fresh mass and total dry mass (Table 4).

Each species behaved differently to certain substrate conditions, which may be favourable or unfavourable, as this has great influence on plant physiology according to Rueda (2014).

Milani (2012), working with seven different substrates for production of *D. chinensis* seedling (a commercial substrate and others consisting of mixtures of soil, rice husk ash, humus and peat), concluded that the use of commercial substrate enabled better development, in its composition there are pine bark and vermiculite (responsible for moisture retention), which are also present in both substrates used in the present work, demonstrating that the substrate composition interferes in plant development.

Considering aerial part length, there was statistical difference between treatments, where in the present work the best result was evidenced by Basaplant<sup>®</sup> substrate, which presented the highest values before the analysis, 5.86 cm and 4.59 cm, respectively, for *L. sinuatum* and *D. chinensis*. As this substrate presented the highest EC and pH value (Table 1), this possibly influenced the results obtained for aerial length, as according to Ludwig et al., (2014) the closer the pH approaches to 7, the greater is the capacity of plant to absorb nutrients and develop, being Basaplant<sup>®</sup> presented pH of 6.0. On the other hand, Kämpf and Firmino (2005) reported that more acidic substrates and with lower EC, the absorption of elements is impaired, which reflects in low development of aerial part, with smaller height, Tropstrato<sup>®</sup> presented the lowest pH and EC (Table 1) and, consequently, the lowest aerial part length (Table 4).

There was no difference for root length, and this is perhaps due to the cell volume in the germination tray may directly affect the size and architecture of the root system, limiting root growth (Francisco et al. 2010) which does not statistically differed one treatment from the other. Furthermore, the substrate density may also influence the root length results (Zorzeto, 2011), as the higher the density, the more difficult the development of the species in the container, however the densities observed in this work (Table 2) do not showed statistical difference and were within the range considered ideal of 0.3 g cm<sup>-3</sup> to 0.4 g cm<sup>-3</sup> by Vifinex (2002).

In Table 1, it is noted that the highest EC value was noted in Basaplant<sup>®</sup> substrate (0.4 dS m<sup>-1</sup>) and consequently it found higher total fresh mass values in Table 4 (0.76 g and 0.38 g for *L. sinuatum* and *D. chinensis*, respectively), differing from the Tropstrato<sup>®</sup> (0.14 g and 0.10 g for *L. sinuatum* and *D. chinensis*, respectively), and this is due to the greater accumulation of salts in substrate, causing higher EC, and thus the energy required by plant to be able to absorb water increases, as each species adapts differently to saline conditions (Rosa et al. 2015).

Even some plants have osmotic adjustment mechanisms and are able to survive, the fact that the plant enters faster under stress conditions causes the stomata closure and, consequently, reduction of photosynthesis rates, translocation of nutrients from the root to the shoot and transpiration, causing it to use physiological mechanisms to avoid excessive water loss (Taiz and Zeiger, 2017), which explains the fact that species grown on Basaplant<sup>®</sup> have greater fresh mass.

However, Basaplant<sup>®</sup> had the lowest water retention capacity result (Table 2) when compared to Tropstrato<sup>®</sup>, but, as observed in Table 1, the EC increased for Tropstrato<sup>®</sup> during the experiment, and according to Sá et al. (2015), an increase in EC may change the plant physiology, interfering with water absorption, which explains the fact that Tropstrato<sup>®</sup> higher water retention capacity (Table 2) did not correspond to the highest fresh mass value (Table 4).

For dry mass, Basaplant<sup>®</sup> provided better results (0.08 g and 0.04 g for *L. sinuatum* and *D. chinensis*, respectively), with statistical difference between treatments. In works with potted gerbera, Ludwig et al. (2010) found that the highest dry mass values of cultivated plants were found with the use of commercial substrate (15% peat + 15% vermiculite + 70% pine bark) compared to other compositions, stating that depending on the materials that substrate is made, there may be changes in plant responses. In the present study, the Basaplant<sup>®</sup> substrate composition was the same as mentioned by the author (pine bark + peat + expanded vermiculite) and this one presented the best results.



#### 4. Conclusion

The emergence of *Limonium sinuatum* and *Dianthus chinensis* were impaired, possibly due to low electrical conductivity provided by substrates. The use of Basaplant® favoured the species development, which is recommended the plants.

#### Acknowledgments

The authors would like to thank the *Agristar do Brasil* company for the donation of *Limonium sinuatum* and *Dianthus chinensis* Topsed®.

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