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Seedlings production of *Gomphrena globosa* and *Petunia x hybrida* in different times and substrates

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Abstract

This study aimed to evaluate the seedlings growth of *Petunia x hybrida* and *Gomphrena globosa* at different times and substrates based on agricultural residues. A completely randomized experimental design was adopted, in a factorial scheme, with treatments consisting of four replications and the experimental unit formed by ten plants. The flower species *Petunia x hybrida* and *G. globosa* were cultivated in five substrate compositions and in two seasons, with sowing carried out in April and June for *Petunia x hybrida* and April and October for *G. globosa*. The substrates were composed using commercial substrate (CM), bovine manure (BM), worm humus (WM) and rice husk ash (HA), in volumetric proportions: (S1) 100% CS; (S2) 40% CS + 20% BM + 20% WH + 20% HA; (S3) 60% CS + 20% WH + 20% HA; (S4) 60% CS + 20% BM + 20% HA; and (S5) 80% CS + 20% BM. Emergence, emergence speed index, height, number of leaves, length of the largest leaf, length of the largest root, dry mass of the aboveground part, dry mass of the root system and total dry mass were evaluated. The seedlings growth of the *Petunia x hybrida* and *G. globosa* changed according to the characteristics of the substrates and the growing seasons. The substrate composed with 80% commercial substrate and 20% bovine manure showed similar or superior results to the commercial substrate and can be used in order to reduce production costs without prejudice to the seedlings growth. The cultivation of *Petunia x hybrida* in April resulted in seedlings with greater height, leaf length and greater accumulation of phytomass. The *G. globosa* seedlings showed greater development of the aboveground part and the root system, in addition to greater accumulation of phytomass when cultivated in October.

Keywords: globe amaranth; petunia; ornamental plants; organic waste.

Produção de mudas de *Gomphrena globosa* e *Petunia x hybrida* em diferentes épocas e substratos

Resumo

Objetivou-se avaliar o crescimento de mudas de *Petunia x hybrida* e *Gomphrena globosa* cultivadas em diferentes épocas e substratos a base de resíduos agropecuários. O delineamento experimental utilizado foi o inteiramente casualizado, em esquema fatorial, sendo os tratamentos compostos por quatro repetições e a unidade experimental formada por dez plantas. Foram cultivadas as espécies de flores *Petunia x hybrida* e *G. globosa* em cinco composições de substratos e em duas épocas, sendo as semeaduras realizadas em abril e junho para a *Petunia x hybrida* e abril e outubro para a *G. globosa*. Os substratos foram compostos utilizando-se substrato comercial (CS), esterco bovino curtido (BM), húmus de minhoca (WH) e cinza de casca de arroz (HA), nas proporções volumétricas: (S1) 100% CS; (S2) 40% CS + 20% BM + 20% WH + 20% HA; (S3) 60% CS + 20% WH + 20% HA; (S4) 60% CS + 20% BM + 20% HA; e (S5) 80% CS + 20% BM. Avaliou-se a emergência, índice de velocidade de emergência, altura, número de folhas, comprimento da maior folha, comprimento da maior raiz, massa seca da parte aérea, massa seca do sistema radicular e massa seca total. O crescimento das mudas de *Petunia x hybrida* e *G. globosa* modificou-se conforme as características dos substratos e as épocas de cultivo. O substrato composto com 80% de substrato comercial e 20% de esterco bovino apresentou resultados semelhantes ou superiores ao substrato comercial, podendo ser utilizado a fim de reduzir os custos de produção sem prejuízos ao crescimento das mudas. O cultivo de *Petunia x*

hybrida em abril resultou em mudas com maior altura, comprimento das folhas e maior acúmulo de fitomassa. As mudas de *G. globosa* apresentaram maior desenvolvimento da parte aérea e do sistema radicular, além de maior acúmulo de fitomassa quando cultivadas em outubro.
Palavras-chave: perpétua; petúnia; plantas ornamentais; resíduo orgânico.

Introduction

The cultivation of ornamental species refers to the agricultural sector aimed at the production of plants that have the purpose of decorating, beautifying and enhancing the environment. The production of flowers is characterized as one of the most promising sectors of horticulture, due its appearance, diversity of shapes, colors, and aromas (MACHADO NETO *et al*., 2013). The market for ornamental plants, especially flowers, has grown 64% between 2012 and 2018, moving a total of R$ 7.9 billion in Brazil this same year (IBRAFLOR, 2020). This increasing expansion in the production of flowers is mainly due to advances in production systems and improvements in the socioeconomic situation of consumers and the consequent increase in demand (JUNQUEIRA; PEETZ, 2017).

Several species of flowers are cultivated to foment a demanding market in quality and constant supply. Among the diversity of ornamental species, the *Petunia x hybrida* excels, belonging to the Solanaceae family, which has tropical and subtropical characteristics, blooms between spring and summer, and is used mainly to decorate gardens (LORENZI, 2013). Another outstanding species among ornamentals is the *Gomphrena globosa*, popularly known as globe amaranth. This is an annual herbaceous ornamental plant, very branched, with simple and hairy leaves, producing small globular inflorescences, with potential to be cultivated in regions with warmer climates, being widely used to compose beds and borders in full sun (LORENZI; SOUZA, 2008).

The production of flowers demands intensive labor and the adoption of technologies specific to each species, adjusting the management practices to the season and place of cultivation (MANIKAS *et al*., 2019), being the production of seedlings in the open field is limited, due to edaphoclimatic and economic factors. Therefore, the cultivation in protected environments, in trays or other containers, seeks to optimize production and thus, there is a need to adopt different models of cultivation associated with the use of different sources and compositions of substrates (MACIEL *et al*., 2016), because stunted seedlings, weakened and of low vigor, will result in plants that are non-uniform and more susceptible to pests and diseases (SANTOS *et al*., 2017). In this sense, the choice of the adequate substrate is a primordial factor at the moment of culture implantation, because its characteristics generally differ greatly from those of the soil (SOLDATELI *et al*., 2020).

The cultivation of plants using substrates is one of the most widely used technologies for cultivation in protected environments. In general, these substrates are composed of more than one component, aiming at the physical and chemical balance of the combination to be used in the production of seedlings, because to obtain quality seedlings these substrates must provide water and nutrients in a balanced way (ARAÚJO *et al*., 2013; LUDWIG *et al*., 2010). Even though there are commercial substrates more recommended for the cultivation of certain species, new sustainable production technologies that supply the need and at the same time are accessible to the economic conditions of the producers must be evaluated (FERREIRA *et al*., 2018). Cultivation in substrates based on agricultural residues can result in plants with greater growth, phytomass accumulation (LUDWIG *et al*., 2010; PÊGO *et al*., 2019) and number of flowers (ALVAREZ *et al*., 2019) in relation to plants grown in commercial substrate. In this sense, the use of ecological waste in the formulation of substrates for seedling production may become an alternative to reduce costs and contribute to a more appropriate disposal of these wastes.

The aim of this study was to evaluate the influence of substrates based on agricultural waste on the growth of seedlings of *Petunia x hybrida* e *G. globosa* in two seasons.

Material and Methods

The experiment was conducted in the greenhouse of the Federal University of Pampa, Itaqui, Rio Grande do Sul (RS), Brazil, with coordinates of 29°09'21.68''S, 56°33'02.58''W and 74 m altitude. According to Köppen's climate classification, the climate is of the type Cfa, subtropical without defined dry season (KUINCHTNER; BURIOL, 2001).

The experimental design used was entirely randomized, with five treatments and four repetitions, and the experimental unit consisted of ten plants. The flower species cultivated were *Petunia x hybrida* e *G. globosa* in five substrate compositions and in two seasons, being the seedings performed in April (SE1) and June (SE2) of the *Petunia x hybrida*, and April (SE1) and October (SE2) for the *G. globosa*. The substrates resulted from a combination of commercial substrate (CS), bovine manure (BM), worm humus (WH) and rice husk ash (HA), in the volumetric proportions: (S1) 100% CS; (S2) 40% CS + 20% BM + 20% WH + 20% HA; (S3) 60% CS + 20% WH + 20% HA; (S4) 60% CS + 20% BM + 20% HA; and (S5) 80% CS + 20% BM. O CS (MecPlant) e WH were purchased at retail locations, the BM obtained after composting the animal manure and the HA obtained as a residue from the rice beneficiation process.

The sowing was performed in expanded polystyrene trays with 128 cells, composed of the formulated substrates and distributed one seed per cell at a depth of 0.50 cm. Each substrate was chemically characterized, and the values of the evaluated properties are expressed in Table 1. The trays were placed on iron benches one meter high and kept in a greenhouse covered with transparent polyethylene of 120 micrometers and laterally covered with a 50% polyolefin screen throughout the experimental period. Irrigation was performed manually according to water demand.

Table 1. Chemical composition of substrates used in the cultivation of seedlings of *Petunia x hybrida* e *G. globosa* in a protected environment.

	Clay	O.M.	V	pH	SMP	P	K	Al	Ca	Mg	H+Al	CTC
	.... %			water	index	mg dm^{-3}		.... $cmol_c$ dm^{-3}				pH7
S1	4	20.0	82.0	5.5	5.6	420	480	0	15.75	14.34	6.9	38.2
S2	4	12.4	79.9	6.1	6.0	500	800	0	6.99	8.38	4.4	21.8
S3	6	14.7	80.1	5.6	6.0	500	728	0	8.64	7.12	4.4	22.0
S4	5	15.7	82.4	5.8	6.1	500	800	0	7.59	8.66	3.9	22.2
S5	4	20.4	79.9	5.6	5.6	500	800	0	11.04	14.34	6.9	34.7

S1 - 100% commercial substrate; S2 - 40% commercial substrate + 20% worm humus + 20% bovine manure + 20% rice husk ash; S3 - 60% commercial substrate + 20% worm humus + 20% rice husk ash; S4 - 60% commercial substrate + 20% bovine manure + 20% rice husk ash; S5 - 80% commercial substrate + 20% bovine manure.

The meteorological values in the experimental area were obtained from the weather station located at about 20 m of the greenhouse. The solar radiation inside the greenhouse was estimated considering the transmissivity of the plastic cover of 63% of the incident solar radiation as said by Schwerz *et al*. (2019). Thus, the solar radiation inside the greenhouse was calculated based on the following expression: SRI = 0.63 x ISR, in which: SRI - solar radiation inside the greenhouse (cal cm^{-2}); ISR - incident of solar radiation on the greenhouse roof (cal cm^{-2}). The photosynthetically active radiation was 45% of the incident solar radiation, according to the values obtained by Assis and Mendez (1989).

After seeding, the number of emerged seedlings was counted, and the emergence velocity index was calculated (EVI). Determined the EVI according to the equation proposed by Maguire (1962): EVI = E1/N1 + E2/N2 + ... En/Nn, (where: EVI = emergence velocity index. E1, E2,... En = number of normal seedlings found at the first count, second count, and last count. N1, N2,... Nn = number of days from seeding to first, second and last count), being considered the period between the first emerged seedling until the constancy of the variable.

The phenometric evaluations of the seedlings were carried out 30 days after seeding, consisting of determining the height - obtained by the distance between the plant base and the last emitted leaf; number of leaves - determined by counting the leaves with the limb fully expanded; length of the largest leaf - determined by the distance between the node and the leaf apex; length of the largest root - obtained through the distance between the plant base to the apex of the largest root. The dry masses of the aboveground part, root system and total dry mass were obtained after drying the seedlings in a forced air oven at 65 °C, removed after 48 hours, and then weighed on precision electronic analytical scales.

The results were submitted to normality analysis, using the Shapiro-Wilk test, and variance homogeneity, using Bartlett's test. Once these two parametric statistical assumptions were met, the data obtained was submitted to the analysis of variance by the F test and the means were compared by the Scott-Knott test at a probability of 5% error.

Results and Discussion

There was an interaction between the factors of seeding seasons and substrates for height, number of leaves, length of the largest leaf and for aboveground dry mass, root dry mass and total dry mass of *Petunia x hybrida* e *G. globosa* (Table 2). For the length of the largest root, there was an interaction between seeding seasons and substrates for the seedlings of *Petunia x hybrida*, being that only the seasons affected the root length of the seedlings of *G. globosa*. The emergence velocity indexes of the two species were affected by the seasons, while the factors did not affect the emergence of seedlings of *Petunia x hybrida*.

Table 2. Analysis of variance for seedling emergence (SEM), emergence velocity index (EVI), height (H), number of leaves (NL), length of the largest leaf (LLL), length of the largest root (LLR), aboveground dry mass (ADM), root system dry mass (RSDM) e total of dry mass (TDM) from seedlings of *Petunia x hybrida* and *G. globosa* grown on different substrates (S) and seasons (SE).

Petunia x hybrida									
MS (Medium Square)									
Factor	**SEM**	**IVE**	**H**	**NL**	**LLL**	**LLR**	**ADM**	**RSDM**	**TDM**
SE	2018^{ns}	31.1*	107.8**	119.4**	391.7**	33.9**	0.11**	0.01^{ns}	0.09**
S	734.7^{ns}	4.5^{ns}	17.5**	86.9**	24.6**	7.3**	0.02**	0.01**	0.04**
SE x S	618.5^{ns}	4.7^{ns}	3.6*	34.5**	4.8**	7.6**	0.01**	0.01**	0.02**
Error	109.8	6.8	1.2	5.6	1.26	2.1	0.01	0.01	0.01
CV%	14.5	16.8	54	23.2	28.5	15.3	54.4	38.8	43.7
Gomphrena globosa									
SE	531.8*	1187*	2.2^{ns}	10.8**	459.1**	25.2**	0.32**	0.03**	0.58**
S	657.4^{ns}	13.1^{ns}	5.2*	3.3**	5.3**	0.7^{ns}	0.01**	0.01*	0.01**
SE x S	220.2*	4.7^{ns}	9.7**	3.7**	5.3**	1.4^{ns}	0.01**	0.01*	0.01**
Error	71.3	6.5	1.6	0.7	1.1	0.87	0.01	0.01	0.01
CV%	10.4	14.3	21.4	11.4	16.5	13.5	34.5	42.6	33.3

** Significant by F test at 1% probability level, *significant by F test at 5% probability level, and ^{ns} non-significant.

The highest values of emergence of seedlings of *G. globosa* grown in the first season (April) were obtained on the substrate S1, consisting of 100% CS, not differing from substrates S3 e S5, consisting of 60% CS + 20% WH + 20% HA e 80% CS + 20% BM, respectively, and there was no significant difference between the substrates in the second season (October) of cultivation (Table 3). These results can be attributed to the higher water holding capacity of substrates with higher organic matter content (Table 1). The higher organic matter content increases the water holding capacity and contributes to the moisture uniformity of the substrates (FIGUEIREDO *et al.*, 2019). Cavalcante *et al.* (2016) evaluating the production of gliricidia seedlings (*Gliricidia sepium* Jacq.) in different substrates, found no differences in the percentage of seed germination between the substrates with organic compounds in the formulation. In relation to the growing seasons, there was an increase in the values of seedling emergence in the second season when grown on the substrates S2 e S4, consisted of 40% CS + 20% WH + 20% BM + 20% HA and 60% CS + 20% BM + 20% HA, respectively, while the seedlings grown on the other substrates were not significantly affected by the seasons.

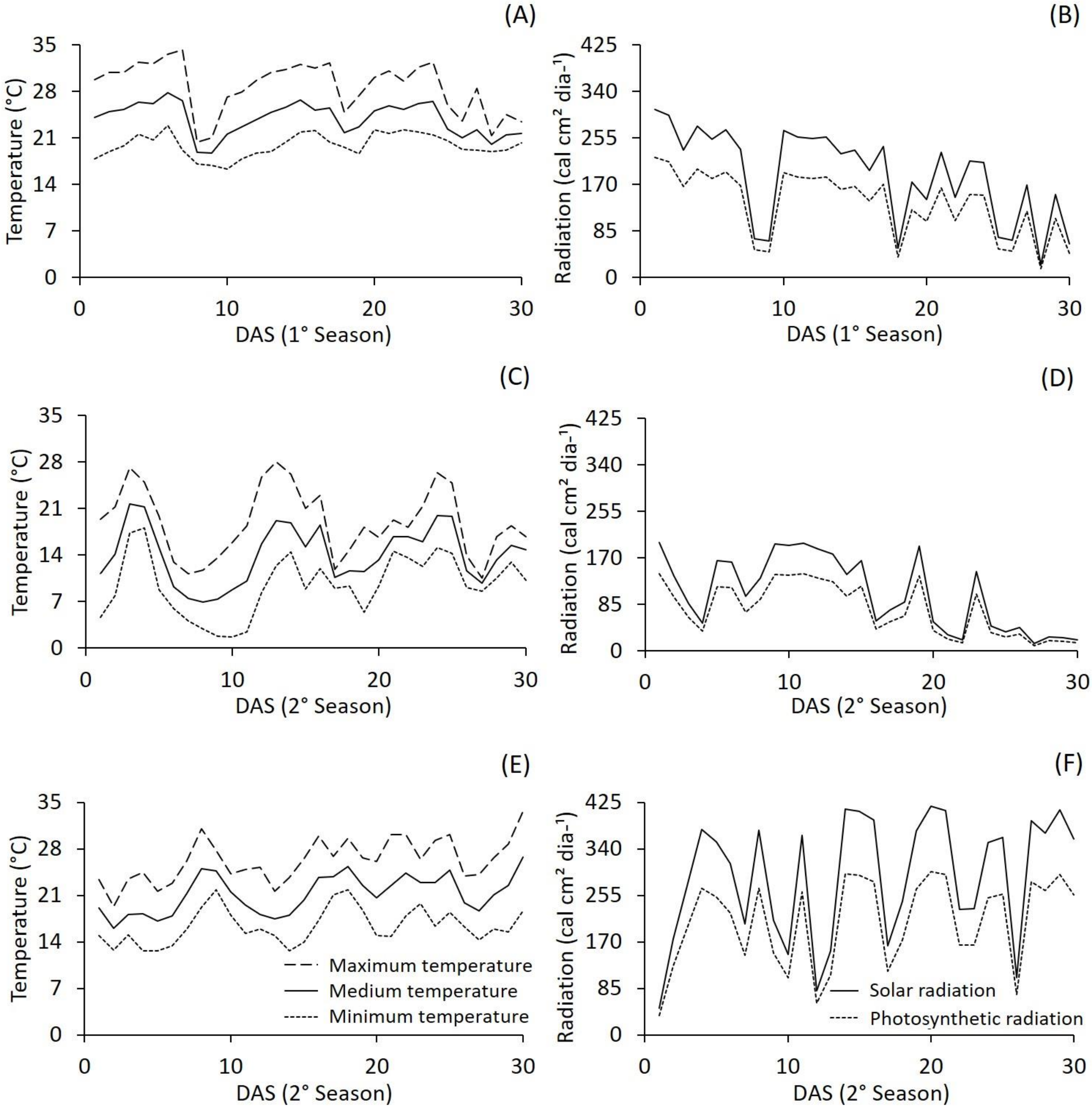
Table 3. Emergence velocity index and emergence of seedlings of *Petunia x hybrida* and *G. globosa* grown on different substrates (S) and seasons (SE).

			Petunia x hybrida		
	S1	**S2**	**S3**	**S4**	**S5**
			Emergence (%)		
SE1	89.58^{ns}	82.29	89.59	89.59	88.54
SE2	93.75	90.63	89.59	84.38	80.21
			Speed of emergence index		
SE1	17.22 a	15.03 a	16.86 a	15.39 a	17.88 a
SE2	15.91 a	15.11 a	14.96 a	13.88 a	13.71 b
			Gomphrena globosa		
			Emergence (%)		
SE1	85.42 aA	67.71 bB	81.25 aA	70.84 bB	81.25 Aa
SE2	84.38 aA	89.59 aA	84.38 aA	85.42 aA	79.17 Aa
			Speed of emergence index		
SE1	9.62 b	13.13 b	13.73 b	13.56 b	11.68 b
SE2	22.94 a	24.65 a	23.67 a	23.57 a	21.37 a

*Means followed by the same lower case letter in the column and capital letters in the row do not differ by the Scott-Knott test at 5% of probability. SE1 – season 1; SE2 – season 2. S1 - 100% commercial substrate; S2 - 40% commercial substrate + 20% worm humus + 20% bovine manure + 20% rice husk ash; S3 - 60% commercial substrate + 20% worm humus + 20% rice husk ash; S4 - 60% commercial substrate + 20% bovine manure + 20% rice husk ash; S5 - 80% commercial substrate + 20% bovine manure.

The emergence speed index of the seedlings of *Petunia x hybrida* differed between the seasons only for seedlings grown on the substrate S5, consisted by 80% CS + 20% BM, being the highest values were obtained in the first season (April) of cultivation (Table 3). Different results were found in the seedlings of *G. globosa*, which presented higher speed of emergence in the second season (October). These results may be due to the temperature of the growing environment (Figure 1) and the intrinsic characteristics of the species. Temperature is one of the main factors that affect the speed and uniformity of germination and emergence, due to its role in the speed of hydration of the seeds and in the biochemical reactions that determine the process of germination and emergence (FERREIRA *et al*., 2013).

Figure 1. Maximum, medium and minimum air temperature, solar radiation and photosynthetically active radiation on days after seeding (DAS) during the first season (A and B) and second growing season of *Petunia x hybrida* (C and D) and *G. globosa* (E and F).



The highest values for plant height of *Petunia x hybrida* were obtained in the substrate S5, consisted of 80% CS + 20% BM, not differing from the substrate S4 consisted of 60% CS + 20% BM + 20% HA only in the second (June) growing season (Table 4). For the *G. globosa*, the highest in the first growing season (April) were obtained in seedlings grown on the substrate S4, not differing for S2 and S5, composed of 40% CS + 20% WH + 20% BM + 20% HA and 80% CS + 20% BM, respectively, and in the second season (October) there was no difference between the substrates evaluated. The results found refer to the nutritional aspects of the substrates for seedling growth (Table 1). Besides being a source of nutrients, organic matter presents surface charges that contribute to the increase of cation exchange capacity of the soil, regulating the availability of various nutrients (ZANDONADI *et al*., 2014). Similar results were obtained by

Ferreira and Rodrigues (2015), which found that substrates composed of bovine manure resulted in papaya seedlings with greater height, independent of the addition of mineral fertilizers.

The growing seasons affected the growth of the species differently, because while the greater heights of *Petunia x hybrida* were obtained in the first season (April), except for S4, composed of the proportions of 60% CS + 20% BM+ 20% HA, for the *G. globosa* there was a greater variation among the seasons according to the substrate (Table 4). This is due to the variation in temperature between growing seasons, because while there was a sharp decrease in average temperatures in the second season (Figure 1C) of the *Petunia x hybrida* relative to the former (Figure 1A), this temperature variation was less pronounced between the growing seasons for *G. globosa* (Figure 1A and 1E). According to Manique (1993), the best conditions for the growth of *Petunia x hybrida* occur at temperatures between 21 and 28 °C. In this sense, the cultivation of *Petunia x hybrida* at lower temperatures, such as those observed in the second growing season (Figure 1C), possibly resulted in the decrease of important physiological reactions for the cellular maintenance of the plants, resulting in decreased water and nutrient uptake and consequently, reduced growth of the seedlings.

Table 4. Height, number of leaves, length of the largest leaf and length of the root system of *Petunia x hybrida* and *G. globosa* grown on different substrates (S) and seasons (SE).

			Petunia x hybrida		
	S1	**S2**	**S3**	**S4**	**S5**
			Height (cm)		
SE1	2.93 aB*	2.91 aB	2.29 aB	2.19 aB	4.17 aA
SE2	1.07 bB	1.51 bB	1.30 bB	1.99 aA	2.32 bA
			Number of leaves		
SE1	9.55 aA	8.33 bA	8.25 bA	9.40 bA	10.05 bA
SE2	8.25 aC	10.53 aB	10.08 aB	12.33 aA	12.15 aA
			Length of the largest leaf (cm)		
SE1	6.40 aA	5.33 aB	4.97 aB	5.36 aB	6.33 aA
SE2	2.42 bC	3.41 bB	2.42 bC	3.61 bB	4.11 bA
			Length of the largest root (cm)		
SE1	9.35 aB	9.39 aB	10.41 aA	11.03 aA	10.06 aA
SE2	9.02 aB	9.11 aB	9.03 bB	9.00 bB	9.97 aA
			Gomphrena globosa		
			Height (cm)		
SE1	5.25 bB	6.41 aA	5.56 aB	6.63 aA	6.14 aA
SE2	6.07 aA	5.74 bA	5.71 aA	5.67 bA	6.07 aA
			Number of leaves		
SE1	7.03 bB	7.70 aA	7.60 bA	7.78 aA	7.15 bB
SE2	7.95 aA	7.53 aB	8.10 aA	7.78 aB	7.55 aB
			Length of the largest leaf (cm)		
SE1	4.81 bB	5.40 bA	4.82 bB	5.46 bA	5.46 bA
SE2	7.49 aA	6.79 aC	7.24 aB	7.30 aB	7.85 aA
			Length of the largest root (cm)		
SE1	6.55 b	6.58 b	6.60 b	6.56 b	6.96 a
SE2	7.00 a	7.38 a	7.12 a	7.22 a	7.05 a

*Means followed by the same lower case letter in the column and capital letters in the row do not differ by the Scott-Knott test at 5% probability. SE1 - season 1; SE2 - season 2. S1 - 100% commercial substrate; S2 - 40% commercial substrate + 20% worm humus + 20% bovine manure + 20% rice husk ash; S3 - 60% commercial substrate + 20% worm humus + 20% rice husk ash; S4 - 60% commercial substrate + 20% bovine manure + 20% rice husk ash; S5 - 80% commercial substrate + 20% bovine manure.

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The values obtained for the number of leaves were different for the two species (Table 4). For *Petunia x hybrida*, there were no significant differences in the first season (April) between substrates, while in the second season (June) the highest values were obtained in S5, composed of 80% CS + 20% BM, not differing only from S4, composed of 60% CS + 20% BM + 20% HA. For *G. globosa*, plants grown on substrate S4 showed the highest values in the first season (April), not differing from S2 and S5, composed of 40% CS + 20% WH + 20% BM + 20% HA and 80% CS + 20% BM, respectively, while in the second growing season (October) there was no significant difference between substrates. The results found refer the chemical properties of the substrates to the growth of the seedlings (Table 1). The use of organic fertilizers in the composition of the substrates contributes to the addition of nutrients and improves soil conditions, promoting increased porosity and aeration (SALLES *et al*., 2017). Moreover, the composition of substrates with organic fertilizers can reduce by up to 37% the leaching of macronutrients important for the initial growth of ornamental plants (ALVAREZ *et al*., 2019).

As for the growing seasons, with the exception of S1, being 100% CS, which did not differ between the seasons, the seedlings of *Petunia x hybrida* showed the highest number of leaves in the second season (June). Similar results were also obtained for *G. globosa*, which except for substrates S2 and S4, composed of 40% CS + 20% WH + 20% BM + 20% HA and 60% CS + 20% BM + 20% HA, respectively, which did not differ between seasons, the highest values were found in the second season (October). These results refer to the environmental conditions during the cultivation of the species, because while the temperature presented itself as the main variation between the seasons *Petunia x hybrida* (Figures 1A and 1C), the variation in solar radiation between growing seasons may have been a determining factor in the leaf emission of *G. globosa* (Figures 1B and 1F). The growth rate normally decreases as the temperature decreases, so milder weather conditions tend to favor and stimulate vegetative growth. (VAID *et al*., 2014). From this, the temperature presents high relevance in the development of the plant, being able to alter the duration of phenological phases according to the accumulated degree days (SCHWERZ *et al*., 2019). On the other hand, it is known that photosynthesis increases with increasing radiation intensity (KLARING; KRUMBEIN, 2013). In this sense, possibly the increased radiation intensity stimulated the plant to direct more carbohydrates to the emission and formation of vegetative structures.

The highest values for the length of the largest leaf of the *Petunia x hybrida* in the first growing season (April) were obtained in plants grown in substrate S1, composed of 100% CS, not differing from S5, composed of 80% CS + 20% BM, while in the second season (June) the highest values were found in substrate S5 (Table 4). In relation to *G. globosa*, again, substrate S5 showed the highest values, regardless of growing season, not differing in the first season (April) from substrates S4 and S3, composed of 60% CS + 20% BM + 20% HA and 60% CS + 20% WH + 20% HA, respectively, and from S1 in the second season (October). These results are due to the chemical properties of the substrates, especially the macronutrient content (Table 1). Vegetative growth is directly related to nitrogen content, because this element participates in the construction of the chlorophyll molecule and proteins (ARAÚJO *et al*., 2013). However, Koetz *et al*. (2012) evaluating doses of phosphorus in the growth of arugula (*Eruca sativa*), found that as the amount of phosphorus in the soil increased, there was an increase in the chlorophyll content of the leaves, demonstrating that phosphorus interferes in the assimilation of nitrogen by the plant. This aspect can justify the reason why seedlings grown in commercial substrate, even with high levels of organic matter, have not excelled in relation to the emission and size of leaves of *Petunia x hybrida* and *G. globosa* grown in other substrates.

The growing seasons affected the species differently, because while the greatest values for the length of the largest leaf of *Petunia x hybrida* were obtained in the first season (April), for *G. globosa*, except for substrate S4, composed of 60% CS + 20% BM + 20% HA, the greatest values were found in the second season (October). This is certainly due to the variation in solar radiation between growing seasons (Figures 1B, 1D and 1F). The plants alter their morphology according to the edaphoclimatic conditions, and as there is an increase in solar radiation, the greater the rate of emission and expansion of the leaves, and consequently, the greater the leaf area index, increasing the efficiency of the leaves in converting photosynthetically active radiation into phytomass (SCHWERZ *et al*., 2019). Similar results were obtained in tomato plants (*Solanum lycopersicum*), because with the reduction of photosynthesis due to restrictions on incident radiation, there were significant decreases in leaf size and plant dry matter (KLARING; KRUMBEIN, 2013).

As for the length of the largest root of the *Petunia x hybrida*, in the first season (April), the highest values were obtained in seedlings grown on substrate S4, composed of 60% CS + 20% BM + 20% HA, not differing from S3 and S5, composed of 60% CS + 20% WH + 20% HA and 80% CS + 20% BM, respectively, while in the second season (June) the highest values were obtained in seedlings grown on substrate S5 (Table 4). This is certainly due to the organic matter content of the substrates (Table 1). Araújo *et al*. (2013) evaluating the growth of papaya seedlings (*Carica papaya*), obtained the greatest root lengths in substrates with organic composts based on poultry litter and bovine manure. Ferreira and Rodrigues (2015) also found that substrates formulated with higher organic matter content resulted in papaya seedlings with greater root lengths.

Regarding the growing seasons, the highest values of root length of *Petunia x hybrida* seedlings grown on substrates S3 and S4, composed of 60% CS + 20% WH + 20% HA and 60% CS + 20% BM + 20% HA, respectively, were obtained in the first season (April), while there were no significant differences for the other substrates between the two seasons. Different results were found in *G. globosa* seedlings, because with the exception of substrate S5, which showed no significant difference between the seasons, the other substrates showed the highest values of root length in the second season of cultivation (October). Possibly, these results are due to the alteration of the environmental conditions during the seasons, directly affecting the photosynthesis, because in sub or supra optimal conditions, the photosynthetic rate is reduced, and consequently, there is a reduction of the growth rate of the morphological structures of the plant (KLARING; KRUMBEIN, 2013; SCHWERZ *et al*., 2019).

The dry mass of the seedlings showed distinct results among the species (Table 5). The highest values of dry mass of *Petunia x hybrida* were obtained in substrate S5, composed of 80% CS + 20% BM, not differing in the first season (April) of cultivation from substrate S1, 100% CS, and in the second season (June) from substrates S4 and S2, composed of 60% CS + 20% BM + 20% HA and 40% CS + 20% WH + 20% BM + 20% HA, respectively. Regarding the seedlings of *G. globosa*, there was an increase in dry mass in the first season of cultivation (April) with the addition of agricultural waste, regardless of the concentration of compounds, and in the second season (October) the highest values were obtained in the substrate S5, not differing only from the substrate S3, being 60% CS + 20% WH + 20% HA. These results are certainly related to the intrinsic characteristics of the substrates (Table 1).

The use of substrates with slightly higher carbon/nitrogen ratio favors the decomposition and mineralization of a good part of the residues, but still keeps a small part to be decomposed, favoring the continuous release of nutrients throughout the plant cycle (ZANELLO; CARDOSO, 2016). Similar results were obtained by Ferreira and Rodrigues (2015), who found that substrates composed of bovine manure resulted in papaya seedlings with greater phytomass, independent of the addition of mineral fertilizers. This result is of great technical relevance, because the addition of agricultural waste, especially manure, results in seedlings similar to or with greater dry matter than seedlings grown only in commercial substrate, as well as providing nutrients more gradually, which may reduce the need for supplemental mineral fertilization.

Table 5. Aboveground dry mass, root system dry mass and total dry mass of *Petunia x hybrida* and *G. globosa* plants grown on different substrates (S) and seasons (SE).

	S1	S2	S3	S4	S5
Petunia x hybrida					
Aboveground dry mass (g)					
SE1	0.118 aA*	0.091 aB	0.092 aB	0.095 aB	0.127 aA
SE2	0.037 bB	0.067 aA	0.043 bB	0.083 aA	0.087 bA
Root system dry mass (g)					
SE1	0.052 aA	0.036 bB	0.037 aB	0.041 bB	0.050 bA
SE2	0.031 bB	0.057 aA	0.035 aB	0.053 aA	0.062 aA
Total dry mass (g)					
SE1	0.170 aA	0.127 aB	0.129 aB	0.136 aB	0.177 aA
SE2	0.068 bB	0.124 aA	0.078 bB	0.136 aA	0.149 aA
Gomphrena globosa					
Aboveground dry mass (g)					
SE1	0.049 bB	0.074 bA	0.062 bB	0.074 bA	0.063 bB
SE2	0.116 aB	0.104 aC	0.131 aA	0.121 aB	0.136 aA
Root system dry mass (g)					
SE1	0.022 bB	0.031 bA	0.029 bA	0.031 bA	0.030 bA
SE2	0.044 aB	0.048 aB	0.054 aA	0.043 aB	0.050 aA
Total dry mass (g)					
SE1	0.071 bB	0.105 bA	0.091 bA	0.105 bA	0.093 bA
SE2	0.160 aB	0.152 aB	0.185 aA	0.165 aB	0.186 aA

*Means followed by the same lower case letter in the column and capital letters in the row do not differ by the Scott-Knott test at 5% probability. E1 - season 1; E2 - season 2. S1 - 100% commercial substrate; S2 - 40% commercial substrate + 20% worm humus + 20% bovine manure + 20% rice husk ash; S3 - 60% commercial substrate + 20% worm humus + 20% rice husk ash; S4 - 60% commercial substrate + 20% bovine manure + 20% rice husk ash; S5 - 80% commercial substrate + 20% bovine manure.

Seedlings of *Petunia x hybrida* grown on substrates S1 and S3, composed of 100% CS and 60% CS + 20% WH + 20% HA, respectively, showed the lowest values of total dry mass in the second season (June), while there was no significant difference between the seasons in seedlings grown on the other substrates (Table 5). Different results were obtained for *G. globosa*, because the seedlings grown in the second season (October) presented the highest values, regardless of the substrate. These results are certainly related to the growing environment, especially temperature and solar radiation (Figure 1).

While there was a reduction in temperature and radiation in the second growing season of *Petunia x hybrida* in relation to the first (Figures 1A, 1B, 1C and 1D), the opposite occurred for solar radiation between the growing seasons of *G. globosa* (Figures 1B and 1F), and the temperature did not show much variation between the seasons. The best conditions for growth of *Petunia x hybrida* occur at temperatures between 21 and 28 °C (MANIQUE, 1993), suboptimal or supraoptimal temperatures reduce the growth rate of the aboveground part and the emission of vegetative structures, thus resulting in low phytomass production (VAID *et al*., 2014). On the other hand, the accumulation of dry mass is also influenced by the photosynthetically active radiation intercepted by the plant, because as the amount of photosynthetically active radiation available increases, the greater is the accumulation of phytomass (SCHWERZ *et al*., 2019). In this sense, the growing seasons resulted in seedling mass accumulation differently, mainly as a function of temperature for *Petunia x hybrida* and solar radiation for *G. globosa*.

Conclusions

The growth of *Petunia x hybrida* and *G. globosa* seedlings modified according to the characteristics of the substrates and the growing seasons. The substrate composed of 80% commercial substrate and 20% bovine manure showed results similar or superior to the commercial substrate and can be used without harming the growth of the seedlings. April cultivation benefited the growth of *Petunia x hybrida* seedlings, while *G. globosa* seedlings showed greater development of the aboveground part, root system and accumulation of phytomass when cultivated in October.

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