DOI: http://dx.doi.org/10.1590/1678-4499.439

SOIL AND PLANT NUTRITION - Article

Substrates and containers for the development of *Brassica pekinensis* L. seedlings

Hozano de Souza Lemos Neto*, Rebeca de Araújo Torres, Lydio Luciano de Gois Ribeiro Dantas, Cícera Vanuza Viana Xavier, Marcelo de Almeida Guimarães, Roberto Jun Takane

Universidade Federal do Ceará - Departamento de Fitotecnia - Fortaleza (CE), Brazil.

ABSTRACT: The aim of this study was to evaluate the development of Chinguensai (*Brassica pekinensis* L.) seedlings, under different formulations of substrates and sizes of containers, in Fortaleza, Ceará. For this, two studies were conducted in factorial design with randomized blocks and four replicates. The first study was conducted in a factorial (4 × 4) design. Four substrate formulations (powder-type coconut fiber; carbonized rice hull and earthworm casting) had the following proportions: S1 (1:1:1); S2 (0:1:1); S3 (1:0:1); and S4 (0:0:1) by volume basis (v/v) and four evaluation dates (22, 27, 34 and 41 days after sowing — DAS). The second study was conducted in a factorial (3 × 4) design with three types of containers with different cell volumes (31, 18 and 11 cm^3) and four evaluation dates (22, 27, 34 and 41 DAS). The fresh and dry weight of the shoot and root systems was evaluated. Both studies showed no interaction between the variables, with differences noted for substrate factors, containers and times in all traits. In the first study, the earthworm compost resulted in the highest yield of fresh and dry seedling weight. In the second study, the container with 31 cm^3 of cell volume showed the highest production of fresh and dry weights. The results showed that the substrate composed solely of earthworm humus and with the use of trays with 31 cm^3 of cell volume provided seedlings of Chinguensai with the optimal production for transplanting 41 DAS.

Key words: evaluation dates, earthworm casting, cell size.

INTRODUCTION

The Chinguensai (*Brassica pekinensis* L.) is a vegetable of Chinese origin. The species are popularly known by the names cabbage, kale or Chinese chard (Silva et al. 2011). Its use in food is associated with the high nutritional value present in plants of this family (Brassicaceae), which re rich in calcium, potassium, vitamins A, C and folic acid (Filgueira 2008).

Belonging to the Brassica genus, the Chinguensai is a biennial, although it is commercially grown as an annual plant. When adult, it has unrestricted and cup-shaped leaves with sizes ranging from 30 to 40 cm. However, it does not form a head as the chard (*Beta vulgaris var. Cicla*). The petioles of the leaves are thick and fleshy (Feltrim et al. 2003; Bezerra 2003; Embrapa 2011).

There are no studies, to date, aimed to improve the production of these species in the Northern and Northeastern regions. Chinese cabbage production provides an alternative income to producers as well as a new source of food to the population.

In this particular context, the evaluation of the seedlings production in containers and the particular substrates used are considered important steps for the production process, especially at the initial stages of the development. According to Kano et al. (2008), the correct selection of containers and substrates for the production of vegetables can allow a better use of other inputs employed in their production, providing saving in seed costs, ease in cultivation and a reduction of failures in the planting area, resulting in a greater economic efficiency in the cultivation.

In order to maximize the efficiency of seedling production in nurseries, the horticultural industry has developed trays with a smaller cell volume. This process, while improving production efficiency, may also negatively affect the productivity of the species (Maggioni et al. 2014). In general, research results have shown that larger containers provided better conditions for the seedlings to develop (Oliveira →

*Corresponding author: hozanoneto@hotmail.com

Received: Sept. 15, 2015 – Accepted: Dec. 17, 2015

et al. 2011; Costa et al. 2011; Guimarães et al. 2012). On the other hand, smaller cells result in substrate savings and in increased number of plants per area.

Nevertheless, for the sake of good seedling production, one must take into consideration the nutritional characteristics of the substrate as well as its physical features that allow the production of quality seedlings, even in smaller-sized containers. The substrate's main function is to provide physical and nutritional support for the plants in the early stages of growth. Through its solid phase, the substrate influences the maintenance of the root system, water supply and nutrients; the liquid phase acts in the supply of oxygen and carbon transport between the roots and the outside air by the gas phase, therefore, improving water, air and nutrient availability (Tessaro et al. 2013). Furthermore, it should also present good aeration attributes that allow the diffusion of oxygen in the roots, and good structure and suitable levels of essential nutrients, pH, texture and Cation Exchange Capacity (CEC) as well (Vitti et al. 2007; Silva et al. 2009).

Based on the aforementioned and taking into account the wide range of containers and substrates available on the market for the production of seedlings, the goal of this study was to evaluate the development of Chinguensai (*Brassica pekinensis* L.) seedlings, under different formulations of substrates and size of containers, in Fortaleza, Ceará.

MATERIAL AND METHODS

The experiments were conducted at the Department of Plant Science at the Universidade Federal do Ceará (UFC), located on the Pici Campus, Fortaleza, at lat 03°36'6"S, long 37°48'36"W and 21.0 masl. The climate, according to the Köppen climate classification, is the Aw' type, i.e. rainy tropical with an average annual rainfall of 1,338 mm, a relative humidity of 75%, a minimum and maximum temperature average of 23 ± 2 °C and 30 ± 2 °C with an annual average of 27 °C.

Both experiments were conducted with white polyethylene film, diffuser with a thickness of 150 microns and a shade cloth in black coloration, retaining 70% of the solar radiation flux. Inside the greenhouse, environmental conditions were recorded throughout the entire studies with a minimum and maximum temperature average of 25.7 and 38.7 °C and relative humidity of 54.7% in the termohigrograph brand Minipa, MT-241 code.

For the development of our studies, we used a hybrid of Chinguensai, the Chouyou cultivar (Takii Seed), being an exotic species, which has studies duly done in the Northern and Northeastern regions.

The two experiments were conducted in a randomized block factorial design with four replicates. The first experiment was developed in factorial (4 × 4) with four substrates formulations (powder-type coconut fiber; carbonized rice hull; earthworm casting) according to the following proportions: S1 (1:1:1); S2 (0:1:1); S3 (1:0:1); and S4 (0:0:1) by volume (v/v) and four different ages (22, 27, 34 and 41 days after sowing — DAS). The materials used to prepare the substrates can be obtained through local commercial suppliers or be produced on-farm, as performed by the authors in this research. The physical and chemical compositions of the S1, S2, S3 and S4 substrates are shown in Table 1. In this particular study, we used polypropylene trays of 200 cells, each filled with the previously prepared substrate formulations.

The second experiment was conducted in a factorial (3 × 4) design with three types of containers with different cell volumes — 31 cm^3 (162 cells), 18 cm^3 (200 cells) and 11 cm^3 (450 cells) — as well as four different ages (22, 27, 34 and 41 DAS) in order to determine the best period for transplanting the seedlings. Earthworm humus was used to supplement the contents of the growing media on each pot.

In both of the above-stated studies and for each treatment, six plants per replication were evaluated. Irrigation was carried out twice daily always keeping the substrate at near field capacity.

At different dates set for the evaluation in each of the experiments, the plants were duly collected and taken to the laboratory in order to determine the following parameters: (a) shoot length (CPA, cm); (b) length of the root system (CSR, cm); (c) total length of seedling (CTP, cm); (d) diameter (DIAM, cm); (e) number of leaves (NF); (f) root:shoot ratio (ROOT/PA); (g) shoot fresh weight (MFPA, g); (h) root fresh weight (MFSR, g); (i) total seedling fresh weight (MFT, g); (j) shoot dry mass (MSPA, g); (k) dry mass of the root system (MSSR, g); and (l) total mass of dry seedling (MST, g).

To determine the CPA, CSR and CTP, plantlets were removed from the cells of the trays with the substrate placed in a water basin for the removal of the substrate in order to not affect the root system; then the plantlets were →

slightly dried with absorbent paper and after measures the stem diameter with a scale in millimeters, using a digital caliper. After the measurements, the seedlings were cut, separating the shoot from the root system, then weighed on a precision balance to determine the MFPA, MFSR and MFT. After weighing the fresh weight of the individual parts of the plants, these were individually wrapped in paper bags and dried inside a forced-air oven at 60 °C to a constant weight to obtain the MSPA, MSSR and MST.

The results were submitted to analysis of variance ($p \leq 0.01$ and $p \leq 0.05$). The Scott-Knott test was set at $\alpha = 0.05$, which was used to compare means when substrates, containers and seasons were significant factors.

RESULTS AND DISCUSSION

Regarding the first study, no interaction was found between the substrate variable and the evaluation times. However, differences were detected in the substrates and within the evaluation times for the length of the shoot and the seedling diameter, number of leaves, root:shoot ratio, fresh and dry shoot, as well as roots and the respective totals (Tables 2 and 3).

Among the formulations of the studied substrates, earthworm humus alone was able to provide better conditions for the development of seedlings in all the evaluated dates. Kiehl (1985) cited that, despite being low in clay, earthworm humus is rich in organic matter, nitrates, phosphorus, potassium, calcium and magnesium, with high CEC and base saturation (V%), as well as high percentage in the equivalent

Table 1. Chemical analysis of substrates composed of equal parts of powder-type coconut fiber, carbonized rice hull and earthworm humus (S1); carbonized rice hull and earthworm humus (S2); powder-type coconut fiber and earthworm humus (S3) and just earthworm humus (S4). Fortaleza, Ceará, 2014.

Substrates	pH	P	K	Na	Cu	Fe	Mn	Zn	Ca	Mg	Al	(H + Al)	CEC	N	MO	Ds
		($mg \cdot dm^{-3}$)							($cmol_c \cdot dm^{-3}$)					$g \cdot kg^{-1}$		$g \cdot cm^{-1}$
S1	7.19	811.00	1,236.80	301.90	0.58	13.30	64.50	43.22	71.65	5.17	0.00	0.00	19.28	6.23	71.65	0.26
S2	6.66	931.20	1,576.80	362.80	0.61	12.70	89.90	50.51	62.77	5.55	0.00	3.14	25.55	6.86	62.77	0.48
S3	6.68	877.80	1,391.30	413.70	0.57	10.80	52.30	45.42	48.04	7.37	0.00	3.14	22.39	4.48	48.04	0.39
S4	6.72	1,051.5	2,782.40	850.40	0.53	0.50	44.20	25.31	52.28	14.40	0.00	3.22	43.63	25.31	52.28	0.82

All the factors were analyzed according to the methodology of Silva et al. (1998). pH = Hydrogen potential: H_2O (1:2.5); P = Phosphorus; K = Potassium; Na = Sodium; Cu = Copper; Fe = Iron; Mn = Manganese; Zn = Zinc; Ca = Calcium; Mg = Magnesium; Al = Aluminum; (H + Al) = Potential acidity; CEC = Cation exchange capacity; N = Nitrogen; MO = Organic matter; Ds = Substrate density. Mehlich extractor.

Table 2. Mean shoot length, length of the root system, total seedling length, stem diameter, number of leaves and the root:shoot ratio of Chinguensai 'Chouyou' seedlings grown in different substrate types and evaluated at different growth stages (22, 27, 34 and 41 days after the sowing). Fortaleza, Ceará, 2014.

Substrates	CPA (cm)	CSR (cm)	CTP (cm)	DIAM (mm)	NF	ROOT/PA
S1	3.50 d	10.40 a	13.90 b	1.30 c	2.45 d	0.41 a
S2	4.30 c	11.13 a	15.44 a	1.33 c	2.91 c	0.39 a
S3	5.11 b	10.96 a	16.07 a	1.48 b	3.22 b	0.35b
S4	7.12 a	9.64 a	16.77 a	1.62 a	3.48 a	0.31 b
Ages	**CPA (cm)**	**CSR (cm)**	**CTP (cm)**	**DIAM (mm)**	**NF**	**ROOT/PA**
22	4.59 c	9.89 a	14.48 b	1.34 b	2.60 c	0.43 a
27	4.70 c	10.90 a	15.61 a	1.35 b	2.82 c	0.34 b
34	5.19 b	10.94 a	15.96 a	1.51 a	3.10 b	0.34 b
41	5.56 a	10.40 a	16.14 a	1.53 a	3.55 a	0.35 b
CV (%)	**8.39**	**14.92**	**10.37**	**8.72**	**10.65**	**20.06**

Means followed by the same letter in the column do not differ statistically according to the Scott-Knott test, at 0.05 probability. CPA = Shoot length; CSR = Length of the root system; CTP = Total length of seedling; DIAM = Diameter; NF = Number of leaves; ROOT/PA = Root:shoot ratio; S1 = Substrate composed of equal parts of powder-type coconut fiber, carbonized rice hull and earthworm humus; S2 = Substrate composed of equal parts of carbonized rice hull and earthworm humus; S3 = Substrate composed of equal parts of powder-type coconut fiber and earthworm humus; S4 = Substrate composed of earthworm humus; CV (%) = Coefficient of variation.

Table 3. Mean shoot fresh weight, root fresh weight, total fresh weight, dry weight of shoot, dry root weight and the total dry mass of Chinguensai 'Chouyou' seedlings developed in different substrate types and evaluated with different ages (22, 27, 34 and 41 days after sowing). Fortaleza, Ceará, 2014.

Substrates	MFPA (g)	MFSR (g)	MFT (g)	MSPA (g)	MSSR (g)	MST (g)
S1	0.10 c	0.01 c	0.12 c	0.01 c	0.007 d	0.025 d
S2	0.15 c	0.01 c	0.17 c	0.02 c	0.009 c	0.034 c
S3	0.25 b	0.03 b	0.28 b	0.03 b	0.011 b	0.047 b
S4	0.50 a	0.06 a	0.57 a	0.06 a	0.019 a	0.083 a
Ages	**MFPA (g)**	**MFSR (g)**	**MFT (g)**	**MSPA (g)**	**MSSR (g)**	**MST (g)**
22	0.20 b	0.03 a	0.24 b	0.02 c	0.010 b	0.037 c
27	0.20 b	0.02 b	0.23 b	0.03 c	0.009 b	0.040 c
34	0.23 b	0.02 b	0.26 b	0.03 b	0.011 b	0.047 b
41	0.37 a	0.03 a	0.40 a	0.04 a	0.016 a	0.064 a
CV (%)	**27.28**	**30.92**	**26.78**	**26.88**	**20.41**	**24.27**

Means followed by the same letter in the column do not differ statistically according to the Scott-Knott test, at 0.05 probability. MFPA = Shoot fresh weight; MFSR = Root fresh weight; MFT = Total seedling fresh weight; MSPA = Shoot dry mass; MSSR = Dry mass of the root system; MST = Total mass of dry seedling; S1 = Substrate composed of equal parts of powder-type coconut fiber, carbonized rice hull and earthworm humus; S2 = Substrate composed of equal parts of carbonized rice hull and earthworm humus; S3 = Substrate composed of equal parts of powder-type coconut fiber and earthworm humus; S4 = Substrate composed of earthworm humus. CV (%) = Coefficient of variation.

moisture. It was also verified in this study that the earthworm humus (S4) had the highest concentration of macronutrients, such as nitrogen, phosphorus, potassium, calcium and magnesium, as compared to the other substrates (S1, S2 and S3) (Table 1). A greater absorption of plant nutrients and water availability would result in a better plant growth performance. This was verified for the S4 substrate, which had a higher moisture content and a higher amount of macronutrients, hence providing better developed seedlings.

According to Taiz and Zeiger (2013), the macronutrients are essential elements for plant growth, being used in larger proportions. Furthermore, with a lower concentration of these nutrients, in a given amount of substrate, the plant tends to quickly deplete the medium of these stated nutrients, resulting in plant stress from a nutritional deficiency. This results in a reduced plant growth and a lesser accumulation of fresh and dry weight, which was not observed in this work with the earthworm humus treatment. Such results are in accordance with the observations by Bezerra (2003), who indicates that, depending on the types of materials used in substrates formulation, nutrient levels are not always sufficient to promote the satisfactory development of the seedlings. In later stages of deficiency, chlorosis and necrosis can be identified in the tissues, as observed in almost all substrates evaluated at 41 DAS, except for the Chinguensai seedlings developed with the earthworm humus. According to Malavolta (2006), these symptoms are typical with nutritional deficiency in minerals, such as potassium and nitrogen.

Lower micronutrient concentrations of copper, iron, manganese and zinc, in the earthworm castings compared to the other substrates (S1, S2 and S3), appeared to have no negative influence in the development of the Chinguensai seedlings. Despite these nutrients being considered essential for the plant development, they are used in lower concentrations (Malavolta 2006; Taiz and Zeiger 2013), which possibly did not result in any damage to the plants. The concentrations of those micronutrients in substrates appear to have been sufficient for the establishment of an initial seedling growth.

Regarding the different dates of assessment, at 41 DAS, the plants showed a better development in terms of growth and yield with respect to fresh and dry weight. Hence, the substrates with higher macronutrient contents resulted in improved seedling growth at 41 DAS.

With reference to the second study, no interactions were observed between the main variables. Nevertheless, differences were found only for the containers and the evaluation dates for shoot growth, fresh and dry shoot weight and for roots, as well as for the whole plant (Tables 4 and 5).

Among the studied containers, those with 162 cell trays with an individual volume of 31 cm^3 per cell had the optimal volume to provide the best conditions for seedling development, possibly by providing greater space for root →

Table 4. Mean shoot length, length of the root system, total seedling length, diameter, number of leaves and the root:shoot ratio of the Chinguensai 'Chouyou' seedlings grown and evaluated in different containers with different ages (22, 27, 34 and 41 days after sowing). Fortaleza, Ceará, 2014.

Containers (cm^3)	CPA (cm)	CSR (cm)	CTP (cm)	DIAM (mm)	NF	ROOT/PA
31	8.40 a	10.18 a	18.58 a	1.83 a	3.71 a	0.323 a
18	7.12 b	9.64 a	16.77 b	1.62 b	3.48 a	0.318 b
11	7.23 b	8.12 b	15.35 c	1.64 b	3.47 a	0.307 b
Ages	**CPA (cm)**	**CSR (cm)**	**CTP (cm)**	**DIAM (mm)**	**NF**	**ROOT/PA**
22	6.84 d	9.40 a	16.24 a	1.75 a	3.84 b	0.411 a
27	7.33 c	9.65 a	16.99 a	1.64 a	3.75 a	0.273 b
34	7.83 b	8.88 a	16.72 a	1.72 a	3.20 b	0.279 b
41	8.33 a	9.31 a	17.65 a	1.68 a	3.80 a	0.301 b
CV (%)	**7.46**	**14.38**	**8.76**	**11.19**	**13.40**	**23.75**

Means followed by the same letter in the column do not differ with the Scott-Knott test, at 0.05 probability. CPA = Shoot length; CSR = Length of the root system; CTP = Total length of seedling; DIAM = Diameter; NF = Number of leaves; ROOT/PA = Root:shoot ratio; CV (%) = Coefficient of variation.

Table 5. Mean shoot fresh weight, root fresh weight, total fresh weight, dry weight of shoot, dry root weight and the total dry mass of Chinguensai 'Chouyou'seedlings grown and evaluated in different containers at different growth stages (22, 27, 34 and 41 days after sowing). Fortaleza, Ceará, 2014.

Containers (cm^3)	MFPA (g)	MFSR (g)	MFT (g)	MSPA (g)	MSSR (g)	MST (g)
31	0.81 a	0.098 a	0.911 a	0.090 a	0.027 a	0.118 a
18	0.50 b	0.066 b	0.573 b	0.063 b	0.019 b	0.083 b
11	0.48 b	0.053 b	0.539 b	0.060 b	0.017 b	0.070 b
Ages	**MFPA (g)**	**MFSR (g)**	**MFT (g)**	**MSPA (g)**	**MSSR (g)**	**MST (g)**
22	0.46 b	0.085 a	0.555 b	0.051 c	0.020 b	0.071 b
27	0.62 b	0.065 b	0.686 b	0.070 b	0.019 b	0.090 b
34	0.54 b	0.058 b	0.602 b	0.071 b	0.019 b	0.090 b
41	0.77 a	0.082 a	0.853 a	0.092 a	0.027 a	0.120 a
CV (%)	**31.10**	**35.05**	**30.98**	**29.80**	**27.53**	**28.38**

Means followed by the same letter in the column do not differ with the Scott-Knott test, at 0.05 probability. MFPA = Shoot fresh weight; MFSR = Root fresh weight; MFT = Total seedling fresh weight; MSPA = Shoot dry mass; MSSR = Dry mass of the root system; MST = Total mass of dry seedling; CV (%) = Coefficient of variation.

development, consequently, allowing a higher absorption of water and nutrients for seedling development.

Similar results were observed by Guimarães et al. (2012), working with jurubeba (*Solanum paniculatum*) and cocona (*Solanum sessiliflorum* Dunal) seedlings, which observed with a higher length, fresh and dry shoot weight for seedlings grown in containers with a larger volume (32.61, 40 and 250 cm^3) and consequently with more substrate availability. Additionally, Donega et al. (2014), who evaluated containers and substrates for the production of seedlings and hydroponic cultivation of thyme (*Thymus vulgaris* L.), also observed a greater development when seedlings were produced in large-sized trays (32.61, 40 and 250 cm^3). Leal et al. (2011), working with the production of beet and lettuce seedlings in Aquidauana, Mato Grosso do Sul, observed satisfactory results with trays of 72 cells (121.2 cm^3) filled with substrate containing 7% organic compounds for both species. Rodrigues et al. (2010), working with the production of tomato seedlings in different substrates and containers in the greenhouse, found higher values for root and shoot fresh weight when containers were used with larger volumes of cells (22.3, 34.6 and 121.2 cm^3), considering the same compound filling. The results obtained in this research and also observed in others confirm the statements made by Nesmith and Duval (1998) as well as Pereira and Martinez (1999) that the absorption of nutrients is affected by the restriction in root growth, mainly caused by the container's size. Therefore, it is understood that the smaller (11 cm^3) the space available to the roots and the lower the amount of substrate, the more difficult to ensure optimal seedling growth and development (Maggioni et al. 2014). Even though several studies indicated that the use of containers with larger volumes of cells (31, 34.6 and 40 cm^3) are better for seedling production, smaller cell volume containers (11 cm^3) may also produce seedlings with appropriate aspects; however, these would have to be transplanted into the field before those grown in containers with larger volumes (31, 34.6 and 40 cm^3).

Regarding growth performance, the highest values for all the growth traits were observed at 41 DAS. Therefore, when using smaller cell size containers (11 cm^3), it is important that the transplanting takes place at 30 DAS in order to avoid stress and for the good production of seedlings (Seabra Júnior et al. 2004), as observed in this study, since the seedlings grown in smaller containers (11 and 18 cm^3 volume of cells) at 41 DAS were less developed than those from the larger containers (31 cm^3 volume of cells). After 41 DAS, the seedlings developed in the 162 cells tray showed the best (or the most vigorous) growth.

As a follow-up to the present research, in order to better understand the effect of particular substrate traits on nutrient uptake and crop growth, additional research is needed to identify the effects of substrate texture (for moisture and nutrient retention), nutrient content, and carbon on nitrogen ratios.

CONCLUSION

The earthworm humus substrate, together with the container with 31 cm^3 of volume per cell, resulted in the production of more uniform and vigorous Chinguensai seedlings and may therefore be suitable for field production when the seedlings are transplanted into the field at 41 DAS.

REFERENCES

Bezerra, F. C. (2003). Produção de mudas de hortaliças em ambiente protegido. Fortaleza: Embrapa; [accessed 2016 Apr 7]. http://ainfo.cnptia.embrapa.br/digital/bitstream/CNPAT/7894/1/doc72.pdf

Costa, E., During, L. G. Y., Nagel, P. L., Ferreira, C. R. and Santos, A. (2011). Qualidade de mudas de berinjela submetida a diferentes métodos de produção. Revista Ciência Agronômica, 42, 1017-1025.

Donega, M. A., Ferezini, G., Mello, S. C., Minami, K. and Silva, S. R. (2014). Recipientes e substratos na produção de mudas e no cultivo hidropônico de tomilho (*Thymus vulgaris* L.). Revista Brasileira de Plantas Medicinais, 16, 271-274. http://dx.doi.org/10.1590/S1516-05722014000200016.

Empresa Brasileira de Pesquisa Agropecuária (2011). Catálogo brasileiro de hortaliças. Brasília: Embrapa; [accessed 2016 Apr 7]. http://uc.sebrae.com.br/sites/default/files/institutional-publication/pdf/catalogo_hortalicas.pdf

Feltrim, A. L., Reghin, M. Y. and Van der Vinne, J. (2003). Cultivo do Pak choi em diferentes densidades de plantas com e sem aplicação de nitrogênio. Publicatio UEPG - Ciências Exatas e da Terra, Ciências Agrárias e Engenharias, 9, 7-13. http://dx.doi.org/10.5212/publicatio.v9i02.804.

Filgueira, F. A. R. (2008). Novo manual de olericultura. 3. ed. Viçosa: Editora da UFV.

Guimarães, M. A., Garcia, M. F. N., Damasceno, L. A. and Viana, C. A. (2012). Production of cocona and jurubeba seedlings in different types of containers. Horticultura Brasileira, 30, 720-725. http://dx.doi.org/10.1590/S0102-05362012000400026.

Kano, C., Godoy, A. R., Higuti, A. R. O., Castro, M. M. and Cardoso, I. I. A. (2008). Produção de couve-brócolo em função do tipo de bandeja e idade das mudas. Ciência e Agrotecnologia, 32, 110-114. http://dx.doi.org/10.1590/S1413-70542008000100016.

Kiehl, A. J. (1985). Fertilizantes orgânicos. Piracicaba: Agronômica Ceres.

Leal, P. A. M., Costa, E., Schiavo, J. A. and Pegorare, A. B. (2011). Seedling formation and field production of beetroot and lettuce in Aquidauana, Mato Grosso do Sul, Brazil. Horticultura Brasileira, 29, 465-471. http://dx.doi.org/10.1590/S0102-05362011000400004.

Maggioni, M. S., Rose, C. B. C. J., Rosa Junior, E. J., Silva, E. F., Rosa, Y. B. C. J., Scalon, S. P. Q. and Vasconcelos, A. A. (2014). Desenvolvimento de mudas de manjericão (*Ocimum basilicum* L.) em função do recipiente e do tipo e densidade de substratos.

Revista Brasileira de Plantas Medicinais, 16, 10-17. http://dx.doi.org/10.1590/S1516-05722014000100002.

Malavolta, E. (2006). Manual de nutrição mineral de plantas. São Paulo: Agronômica Ceres.

Nesmith, D. S. and Duval, J. R. (1998). The effect of size container. Hort Technology, 8, 495-498.

Oliveira, A. C. L., Arrigoni-Blank, M. F., Blank, A. F. and Bianchini, F. G. (2011). Produção de mudas de dois genótipos de alecrim-de-tabuleiro (*Lippia gracilis* Schauer) em função de fertilizante mineral, calcário, substratos e recipientes. Revista Brasileira de Plantas Medicinais, 13, 35-42. http://dx.doi.org/10.1590/S1516-05722011000100006.

Pereira, P. R. G. and Martinez, H. E. P. (1999). Produção de mudas para o cultivo de hortaliças em solo e hidroponia. Informe Agropecuário, 20, 24-31.

Rodrigues, E. T., Leal, P. A. M., Costa, E., Paula, T. S. and Gomes, V. A. (2010). Produção de mudas de tomateiro em diferentes substratos e recipientes em ambiente protegido. Horticultura Brasileira, 28, 483-488. http://dx.doi.org/10.1590/S0102-05362010000400018.

Seabra Júnior, S., Gadun, J. and Cardoso, A. I. I. (2004). Produção de pepino em função da idade das mudas produzidas em recipientes com diferentes volumes de substrato. Horticultura Brasileira, 22, 610-613. http://dx.doi.org/10.1590/S0102-05362004000300022.

Silva, F. C., Eira, P. A., Barreto, W. O., Pérez, D. V., Silva, C. A. (1998). Manual de métodos de análises químicas para avaliação da fertilidade do solo. Rio de Janeiro: EMBRAPA CNPS. Embrapa-CNPS. (Documentos, 3).

Silva, L. J. B., Cavalcante, A. S. S. and Araújo Neto, S. E. (2009). Produção de mudas de rúcula em bandejas com substratos a base de resíduos orgânicos. Ciência e Agrotecnologia, 33, 1301-1306. http://dx.doi.org/10.1590/S1413-70542009000500015.

Silva, M. B., Seabra Júnior, S., Rodrigues, L. F. O. S., Oliveira, R. G., Nohama, M. T. R., Nunes, M. C. M., Inagaki, A. M. and Diamond, M. S. (2011). Desempenho de cultivares de couve-chinesa sob telados e campo aberto. Agrarian, 4, 91-97.

Taiz, L. and Zeiger, E. (2013). Fisiologia vegetal. 5. ed. Porto Alegre: Artmed.

Tessaro, D., Matter, J. M., Kuczmani, O., Furtado, L. M., Costa, L. A. M. and Costa, M. S. S. M. (2013). Produção agroecológica de mudas e desenvolvimento a campo de couve-chinesa. Ciência Rural, 43, 831-837.

Vitti, M. R., Vidal, M. B., Morselli, T. B. G. A. and Faria, J. L. C. (2007). Efeitos de substrato alternativo e comercial na produção de mudas de alface em ambiente protegido. Revista Brasileira de Agroecologia, 2, 1166-1169.