BONIFÁCIO, T. C., RIBEIRO, C. H. M., CARLOS, R. P., COSTA, L. F. Different substrates in the emergence and development of *Passiflora edulis* F. seedlings. **Revista de Agricultura Neotropical**, Cassilândia-MS, v. 12, n. 2, e9316, Apr./June, 2025. ISSN 2358-6303. DOI: https://doi.org/10.32404/rean.v12i2.9316.

Different substrates in the emergence and development of *Passiflora edulis* F. seedlings

Thatyelle Cristina Bonifácio[1], Carlos Henrique Milagres Ribeiro[2], Roni Peterson Carlos[1], Lucas Ferreira Costa[1]

[1] Instituto Federal de Educação, Ciência e Tecnologia do Sudeste de Minas Gerais, Câmpus Barbacena, Barbacena, Minas Gerais, Brasil. E-mail: thaty.cris2013@yahoo.com.br, ronipeterson95@outlook.com, ferreiralucas0720@gmail.com

[2] Universidade Federal de Lavras, Lavras, Minas Gerais, Brasil. E-mail: carlos.ribeiro5@estudante.ufla.br

Received: 09/02/2025; Accepted: 23/05/2025.

ABSTRACT

The production of *Passiflora edulis* L. seedlings from seeds presents unevenness from emergence to the initial development of the seedlings, with the type of substrate being a factor that can influence this process. This study aimed to evaluate alternative substrates' effect on the emergence and development of yellow passion fruit seedlings. Four types of substrates were assessed: soil + cattle manure + fine sand, Bioplant®, earthworm humus, and Bioplant® + earthworm humus. At 30 days after sowing (DAS), seedling emergence potential and phytotechnical parameters were evaluated. At 70 DAS, survival percentage and phytotechnical parameters were assessed. The substrates influenced the emergence potential and initial development of the seedlings. The use of Bioplant® and earthworm humus substrates resulted in a higher seedling emergence percentage and a greater emergence speed index. Seedling survival percentage was influenced by the type of substrate used, being lower when using the substrate composed of soil + cattle manure + sand. The earthworm humus-based substrate provided more leaves, a longer main root length, and a greater shoot length. To achieve higher emergence potential and better seedling development, the use of earthworm humus-based substrates is recommended.

Keywords: *Passiflora edulis Sims*, Seedling quality, Seedling production.

Diferentes substratos na emergência e desenvolvimento de mudas de *Passiflora edulis* F.

RESUMO

A produção de mudas de *Passiflora edulis* L. a partir de sementes apresenta desuniformidade desde a emergência até o desenvolvimento inicial das mudas, sendo o tipo de substrato um fator que pode influenciar esse processo. Este estudo teve como objetivo avaliar o efeito de substratos alternativos na emergência e no desenvolvimento de mudas de maracujazeiro-amarelo. Foram avaliados quatro tipos de substratos: solo + esterco bovino + areia fina, Bioplant®, húmus de minhoca e Bioplant® + húmus de minhoca. Aos 30 dias após a semeadura (DAS), foram avaliados o potencial de emergência das mudas e parâmetros fitotécnicos. Aos 70 DAS, foram avaliados a porcentagem de sobrevivência e os parâmetros fitotécnicos. Os substratos influenciaram o potencial de emergência e o desenvolvimento inicial das mudas. O uso dos substratos Bioplant® e húmus de minhoca resultou em maior porcentagem de emergência das mudas e maior índice de velocidade de emergência. A porcentagem de sobrevivência das mudas foi influenciada pelo tipo de substrato utilizado, sendo menor quando se utilizou o substrato composto por solo + esterco bovino + areia. O substrato à base de húmus de minhoca proporcionou maior número de folhas, maior comprimento da raiz principal e maior comprimento da parte aérea. Para obter maior potencial de emergência e melhor desenvolvimento das mudas, recomenda-se o uso de substratos à base de húmus de minhoca.

Palavras-chave: *Passiflora edulis Sims*, Qualidade de mudas, Produção de mudas.

1. Introduction

Passion fruit (*Passiflora edulis* L.) is one of the most widely produced and consumed fruit species in Brazil (Ramos et al., 2023). This high production is linked to cultivation in various regions of the country, which have tropical and subtropical climates (Silva et al., 2019). According to IBGE data (2022), in 2020, production reached 683,993 tons.

It is highly valued by consumers for its round shape, striking rind color, and nutritional properties, serving as a source of vitamins A and C, carotenoid compounds, and polyphenols, and it is consumed fresh or processed in the industry (He et al., 2020; Bernardo et al., 2024).

Seedling quality is crucial to achieve successful fruit production (Alves et al., 2024). More vigorous seedlings with good environmental adaptability are important (Guerra et al., 2017). However, according to Dias et al. (2022), seedling production remains one of the main challenges for this crop. Since it is performed through seeds, there may be variations in emergence potential, leading to non-uniform seedlings and, in some cases, slow development (Cabral et al., 2023; Oliveira et al., 2023).

The type of substrate directly influences the emergence potential and initial development of seedlings (Silva et al., 2024). Substrates must possess certain physical properties, such as good drainage, macropores, and microporosity, being pathogen-free, providing good nutrient availability, high cation exchange capacity (CEC), and low salt content (Santos et al., 2023).

There are various commercial substrates available in the market for passion fruit seedling production (Cabral et al., 2023). However, associated costs often limit their use (Gonçalves et al., 2016).

In this context, alternative substrates emerge as a viable solution, reducing costs while maintaining yield and quality in seedling production (Nadai et al., 2015). Different combinations and proportions can be used, such as mixtures of soil, sand, and organic residues like cattle manure (Matos *et al*., 2020; Azevedo et al., 2021; Da Silva et al., 2024).

Additionally, organic compounds such as humus can be used as substrate components. Their use benefits soil microbiota, enhances nutrient availability, and promotes seedling development (Santos et al., 2022).

Although alternative substrates show promise, studies on their influence on emergence potential and seedling development are still scarce, especially for passion fruit crops (Alves et al., 2024).

Given this background, this study aimed to evaluate the effect of different alternative substrates on the emergence and initial development of yellow passion fruit (*Passiflora edulis*) seedlings.

2. Material and Methods

The experiment was conducted in a nursery under 50% shade netting at a commercial property named Fazenda das Abóboras, located in the municipality of Barbacena, Minas Gerais, Brazil (21º22'64"S, 43º77'42"W, and an altitude 1173 m). According to the Köppen classification, the climate is Cwb-type (subtropical highland climate, with dry winters and mild summers), with an average annual temperature of 18 °C and precipitation of around 1400 millimeters (INMET, 2022). The climatic data for the experimental period are presented in Figure 1.

Four types of substrates were used, corresponding to the following treatments: Substrate composed of soil + cattle manure + fine sand, in a 2:1:1 ratio; Commercial substrate Bioplant®; Substrate composed of earthworm humus from the company Mogi Fértil®; Commercial substrate Bioplant® + substrate composed of earthworm humus from the company Mogi Fértil®, both in a 1:1 ratio. Information regarding the chemical analysis of the substrates used can be found in Table 1.

After selecting the treatments (substrates), each substrate was used to fill seedling trays with 128 cells. Commercial seeds were obtained from a seed producer and supplier. Two seeds per cell were sown at a depth of 1 cm.

After the onset of emergence, emerged seedlings were counted daily to construct a cumulative emergence curve. Once emergence had stabilized, the percentage of emerged seedlings was evaluated according to the guidelines of the Seed Analysis Manual (Brazil, 2009) and calculated using the following formula:

$$\text{PES} = \frac{N}{100}\, x\, 100 \qquad (1)$$

Where:

PES = Percentage of emerged seedlings

N = Number of emerged seedlings at the end of the test, expressed as a percentage.

The emergence speed index (ESI) was also evaluated and calculated according to Maguire's equation (1968):

$$\text{ESI} = \frac{\text{G1}}{\text{D1}} + \frac{\text{G2}}{\text{G2}} + \cdots \frac{\text{Gn}}{\text{Dn}} \qquad (2)$$

Where:

ESI = Emergence Speed Index

G_1, G_2, ..., G_n = Number of normal seedlings counted at each observation

D_1, D_2, ..., D_n = Number of days from sowing to the 1st, 2nd, ..., last count

The mean emergence time (MGT), expressed in days, was also calculated using the formula:

$$\text{MGT} = \frac{(\sum_{i=1}^{k} \text{ni .ti})}{\sum_{i=1}^{k} \text{ni}} \qquad (3)$$

Where:

MGT = Mean Emergence Time

n_i = Number of seedlings that emerged per day

t_i = Incubation time (days).

All visibly developed leaves on each plant were manually counted to evaluate the number of leaves. Shoot length was measured using a millimeter ruler from the point of insertion at the base of the plant to the tip of the apical bud. A completely randomized design (CRD) was used, with four treatments (different substrate types) and four replications. Each replication consisted of one tray with 128 cells. At 30 days after sowing, when the seeds stabilized, seedlings were transplanted into black polyethylene bags with dimensions of 24 cm in height and 18 cm in diameter, using the same substrates.

Irrigation was performed daily to maintain substrate moisture at field capacity, avoiding excess or insufficient water. At 75 days after transplanting, morphophysiological assessments were conducted to evaluate seedling performance under the experimental conditions.

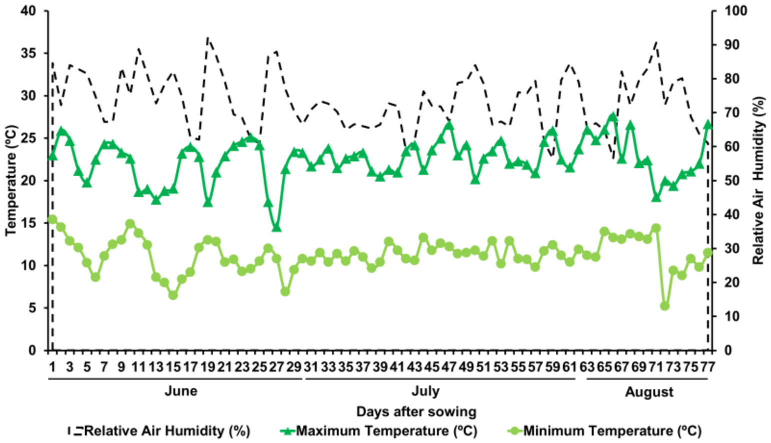

Figure 1. Meteorological data collected during the experiment. Source: Prepared by the authors based on data provided by INMET (2022).

Table 1. Chemical analysis and technical specifications of the substrates used for sowing and forming yellow round passion fruit seedlings.

Chemical analysis of the substrate composed of soil + manure + sand (2:1:1)									
pH	O.M.	P-Rem	K	P	Na		Zn	Fe	Mn
-	dag kg⁻	mg L¹	……………………mg dm^{-3} …………………………						
4.4	2.95	10.0	59.18	0.61	-		0.72	71.27	43.75
Cu	B	S	Ca	Mg	Al	H+ Al	SB	t	t
……. mg dm^{-3}………			………. $cmol_c$ dm^{-3}……….						
3.05	0.06	20.24	1.08	0.20	0.53	6.52	1.43	1.96	7.95
Physicochemical analysis of the commercial substrate Bioplant®									
pH	O.M.	P-Rem	K	P	Na		Zn	Fe	Mn
-	dag kg⁻	mg L¹	……………………mg dm^{-3} …………………………						
6.2	9.85	-	335	104	-		28.2	113.1	4.7
Cu	B	S	Ca	Mg	Al	H+ Al	SB	Mg	
……. mg dm^{-3}………			………. $cmol_c$ dm^{-3}……….						
21.2	2.78	13.21	6.6	5.7	0.0	7.76		12	
Water retention capacity				Electrical conductivity (EC)					Density
100%				0.7					150 kg/m³
Components									
Sphagnum peat			Coconut fiber			Rice husk			
Pine bark			Vermiculite			Agricultural gypsum			
Calcium carbonate			Magnesium			Magnesium-enriched thermophosphate (Yoorin)			
Additives (fertilizers)									
Composition of earthworm humus substrate from the company Mogi Fertil®									
N			P				K		
17% a 28%			22% a 37%				12% a 37%		
Components									
Earthworm humus									
Peat									
Wood sawdust									
Sugarcane bagasse									
Organic compost									

Prepared by the authors based on the chemical analysis and technical specifications of the substrates used (2024).

The following parameters were analyzed:

Seedling survival percentage (SSP) (%): calculated as the ratio between the number of surviving seedlings and the total number of transplanted seedlings, expressed as a percentage.

Number of leaves per seedling: determined by directly counting fully expanded leaves on each plant.

Shoot length (cm): measured using a millimeter ruler from the base of the stem to the apex of the shoot.

Longest root length (cm): after carefully removing the seedlings from the substrate, the root systems were washed to eliminate soil residues, and the length of the longest primary root was measured using a graduated ruler.

The experiment followed a completely randomized design (CRD), with four treatments (different substrates), four replications per treatment, and 15 seedlings per replication.

Data were subjected to analysis of variance, and the means were compared using Tukey's test at a 5% probability level. The analyses were performed using the statistical software SISVAR® version 5.8 (Ferreira, 2011).

3. Results and Discussion

Seedling emergence was evaluated daily, and a seedling was considered emerged when the plumule was visibly above the substrate surface. Based on these observations, emergence curves were constructed for each treatment (Figure 2). Variations were observed in the initial emergence time among the substrates. In the substrates composed of earthworm humus and the mixture of Bioplant® + earthworm humus, seedling emergence began 7 days after sowing (DAS). In the pure Bioplant® substrate, emergence started at 8 DAS. The substrate composed of soil + sand + cattle manure showed the greatest delay, with emergence starting only at 14 DAS.

Differences were also observed in the time required for emergence stabilization. In the Bioplant® and Bioplant® + earthworm humus substrates, stabilization occurred at 23 DAS. In contrast, for the soil + sand + cattle manure and pure earthworm humus substrates, stabilization was reached at 25 DAS.

Research has shown that passion fruit seedling emergence begins around the seventh day after sowing (Welter et al., 2011). In the present study, emergence was also observed starting on the seventh day, confirming these findings. According to Aguacía et al. (2015), seed emergence typically occurs within the first two weeks after sowing.

The emergence time in commercial seeds can vary between 10 days and, in seeds removed from the fruits in some cultivars, it can start in up to three months (Alexandre et al., 2004). One hypothesis for the emergence observed before 10 days in the present study is related to seed quality, climatic conditions, irrigation management, and the specific physical and chemical characteristics of each substrate (Silva et al., 2021; Lessa et al., 2023).

There was variation in the percentage of emerged seedlings (PES) and the emergence speed index (ESI) among the different substrates used (Table 2). Substrates composed of Bioplant® and earthworm humus had the highest values, differing from the others. The substrate composed of soil + cattle manure + sand had the lowest values for the evaluated parameters (Table 2). However, the substrates used did not influence the mean emergence time (MET) (Table 2).

Regarding the parameters of the number of leaves (NL) and shoot length (SL) at 30 days after sowing (Table 2), there were statistical differences among the substrates used. The substrate composed of earthworm humus showed the highest number of leaves (NL) and shoot length (SL), while the soil + cattle manure + sand substrate had the lowest performance compared to the other treatments.

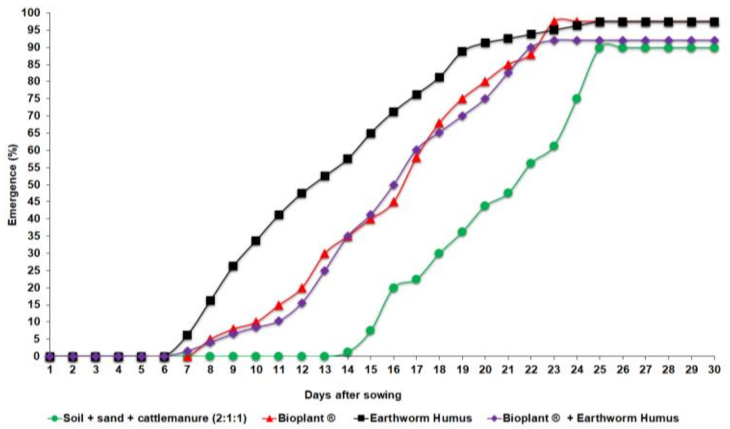

Figure 2. Emergence curve of yellow passion fruit (*Passiflora edulis f. flavicarpa*) grown in different substrates.

Table 2. Percentage of emerged seedlings (PES), emergence speed index (ESI), mean emergence time (MET), number of leaves (NL), and shoot length (SL) of passion fruit seedlings at 30 days after sowing.

Substrates	PES*	ESI	MET
Soil + cattle manure + sand (2:1:1)	89.8 b	0.89 b	1.04 a
Bioplant®	97.5 a	1.70 a	1.05 a
Earthworm humus (Mogi Fértil®)	97.5 a	1.70 a	1.05 a
Bioplant® + Earthworm humus (Mogi Fértil®)	92.0 ab	1.32 ab	1.04 a
CV (%)	7.24	5.41	0.53
Substrates	NF	SL (cm)	
Soil + cattle manure + sand (2:1:1)	3.32 c	4.80 c	
Bioplant®	3.80 ab	4.95 bc	
Earthworm humus (Mogi Fértil®)	3.90 a	5.27 a	
Bioplant® + Earthworm humus (Mogi Fértil®)	3.60 bc	5.00 ab	
CV (%)	1.15	3.36	

* Means followed by the same lowercase letter in the columns do not differ by the Tukey test ($p < 0.05$).

Different substrate compositions influence seed emergence potential, as observed in this study. The higher percentage of emerged seedlings in the Bioplant® and earthworm humus substrates can be attributed to the high proportion of vermicompost in their composition (Santos et al., 2024). These components increase water retention capacity in the soil, promoting efficient seed imbibition, essential for metabolic activities and hormonal balance between abscisic acid and gibberellin (Smolikova et al., 2021).

Parameters such as ESI (emergence speed index) and MET (mean emergence time) are important for understanding the emergence process under field conditions. Higher averages in these parameters indicate greater resistance to abiotic stresses, contributing to the initial development of seedlings (Dan et al., 2010; Ribeiro et al., 2016).

Santos et al. (2014), using substrates composed of earthworm humus and carbonized rice husks, reported that 100% earthworm humus resulted in the greatest number of leaves and the longest shoot length - findings consistent with those of the present study. The use of earthworm humus is a promising alternative for seedling production as it increases the microbial load in the soil and provides essential nutrients for plant development, promoting greater seedling growth (Lim et al., 2015).

The substrates influenced the seedling survival rate (SSR) (Table 3). No significant difference was observed among the Bioplant®, earthworm humus, and Bioplant® + earthworm humus substrates, but the substrate composed of soil + manure + sand showed the lowest seedling survival rate. The substrate composed of earthworm humus presented the greatest root length (RL), number of leaves (NL), and shoot length (SL), with values of 18.21 cm, 10.00, and 25.77 cm, respectively (Table 3).

The substrate composed of soil + cattle manure + sand showed a lower seedling survival percentage, and this may be related to the low aeration and high resistance of the soil to root penetration in the substrate due to a lower proportion of sand present (Santos et al., 2020).

Table 3. Seedling survival percentage (SSP), longest root length (LRL), number of leaves (NL), and shoot length (SL) of passion fruit seedlings at 75 days after sowing.

Substrates	PSM (%)*	LRL (cm)
Soil + cattle manure + sand (2:1:1)	86.67 b	13.33 c
Bioplant®	93.33 a	15.59 bc
Earthworm humus (Mogi Fértil®)	93.33 a	18.21 a
Bioplant® + Earthworm humus (Mogi Fértil®)	93.33 a	16.57 ab
CV (%)	10.21	4.59
Substrates	NL	SL (cm)
Soil + cattle manure + sand (2:1:1)	8.15 b	21.48 b
Bioplant®	9.55 ab	22.23 ab
Earthworm humus (Mogi Fértil®)	10.00 a	25.77 a
Bioplant® + Earthworm humus (Mogi Fértil®)	9.00 ab	23.43 ab
CV (%)	2.20	1.18

*Means followed by the same lowercase letter in the columns do not differ using the Tukey test ($p < 0.05$).

Naumi et al. (2024), evaluating the effect of different proportions of earthworm humus on papaya seedlings, reported that the use of humus led to a higher number of leaves, greater shoot length, and longer root length. Similar results were observed by Santos et al. (2014), who used a substrate composed of 90% earthworm humus to produce yellow passion fruit seedlings.

Based on the literature, the success of using substrates such as earthworm humus is linked to its nutrient-rich composition, including essential elements like nitrogen and potassium, which are crucial for the plant's vegetative development (Batista et al., 2013; Bezerra et al., 2023). The choice of substrate will influence various parameters throughout the plant's development, as it retains nutrient solutions and supports plant anchorage (Schafer; Lerner, 2022).

4. Conclusions

The substrates influence the emergence potential and initial development of yellow passion fruit (*Passiflora edulis*) seedlings.

The use of Bioplant® substrate and Mogi Fértil® earthworm humus resulted in a higher percentage of seedling emergence and a greater emergence speed index.

Substrate selection influences the seedling survival rate, with the lowest survival percentage observed in the substrate composed of soil, cattle manure, and sand.

The earthworm humus substrate (Mogi Fértil®) promoted a higher number of leaves, longer root length, and greater shoot length in passion fruit seedlings.

Authors' Contribution

All authors contributed equally to this manuscript. Thatyelle Cristina Bonifácio, Carlos Henrique Milagres Ribeiro, Roni Peterson Carlos and Lucas Ferreira Costa performed data analysis, writing, and revision. Carlos Henrique Milagres Ribeiro and Thatyelle Cristina Bonifácio conducted text editing. Thatyelle Cristina Bonifácio, Carlos Henrique Milagres Ribeiro, Roni Peterson Carlos, and Lucas Ferreira Costa carried out the experiment and data collection.

Bibliographic References

Aguacía, L.M., Lasprilla, D.M., Carranza, C. 2015. Efecto del estado de madurez del fruto y del período de fermentación sobre la germinación de semillas de maracuyá (*Passiflora edulis* f. *flavicarpa Deg*.) y granadilla (*Passiflora ligularis Juss*.). Agronomia Colombiana, 33(3), 305-314. 10.15446/agron.colomb.v33n3.52460

Alexandre, R.S., Wagner Júnior, A., Negreiros, J.R.D.S., Parizzotto, A., Bruckner, C.H. 2004. Germinação de sementes de genótipos de maracujazeiro. Pesquisa agropecuária brasileira, 39, 1239-1245. https://doi.org/10.1590/S0100-204X2004001200011

Alves, N.F., Linhares, P.C.F., de Assis, J.P., de Almeida Cardoso, E., Sousa, R.P., Alves, L.S., Silva, A.L. 2024. Desenvolvimento de mudas da cultivar de maracujá ufersa Brs rm 153, utilizando substratos orgânicos alternativos da jitirana (*Merremia aegyptia* L.) e palha de carnaúba (*Copernicia prunifera*). Observatório de la economía latinoamericana, 22(6), e5482-e5482. https://doi.org/10.55905/oelv22n6-230

Azevedo, G.A., Costa, C.A.A., Silva-Matos, R.R.S., Azevedo, J.R., Almeida, E.I.B., Sousa, W.S. 2021. Esterco bovino como substrato alternativo na produção de mudas de açaí cultivar BRS-Pará. Revista Brasileira de Agropecuária Sustentável, 11(1). https://doi.org/10.21206/rbas.v11i1.9887

Batista, M.A., Bezerra Neto, F., Ambrósio, M.M., Guimarães, L., Saraiva, J.P.B., Silva, M.L. 2013. Atributos microbiológicos do solo e produtividade de rabanete influenciados pelo uso de espécies espontâneas. Horticultura Brasileira, 31, 587-594. https://doi.org/10.1590/S0102-05362013000400013

Bernardo, C.O., Martins, I.B.A., Peron, T., Martins, M.L., Talma, S.V., Chávez, D.W.H., Martins, E.M.F. 2024. Bebida mista de maracujá com inhame fermentada com bactéria probiótica: avaliação físico-química, microbiológica e sensorial. Interfaces Científicas-Saúde e Ambiente, 9(3), 571-583. https://doi.org/10.17564/2316-3798.2024v9n3p571-583

Bezerra, I.L., Maneti, V.M., Santos, L.S., Nascimento, J.M.S., Alves, C.D., Pereira, V.L. 2023. Substratos orgânicos na produção de mudas de rúcula em região Amazônica. Revista Verde de Agroecologia e Desenvolvimento Sustentável, 18(3), 98-102. 10.18378/rvads.v18i3.9595

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Regras para análise de sementes. Brasília: Mapa/ACS, 399 p. 2009.

Cabral, R.G., Pacheco, A., Adorian, G.C., Silva, R.Z., Leão, E.U., Martins, A.L.L. 2023. Efeitos de diferentes substratos no desenvolvimento de mudas de maracujá. Agri-environmental sciences, 9(2), 5-5. https://doi.org/10.36725/agries.v9i2.8625

Dan, L.G.D.M., Dan, H.D.A., Barroso, A.L.D.L., Braccini, A.D.L. 2010. Qualidade fisiológica de sementes de soja tratadas com inseticidas sob efeito do armazenamento. Revista Brasileira de Sementes, 32, 131-139. https://doi.org/10.1590/S0101-31222010000200016

Dias, D.R., Vale, B.S.C., Santana, J.A.V., Junior, J.R.S. 2022. Produção de mudas de maracujazeiro-amarelo em diferentes níveis de irrigação e formulações de substrato. Nativa, 10(1), 102-108. https://doi.org/10.31413/nativa.v10i1.12330

Ferreira, DF 2011. Sisvar: um sistema computacional de análise estatística. Ciência e agrotecnologia, 35, 1039-1042. https://doi.org/10.1590/S1413-70542011000600001

Gonçalves, F.C.D.M., Arruda, F.P., Sousa, F.L., Araújo, J.R. 2016. Germinação e desenvolvimento de mudas de pimentão Cubanelle em diferentes substratos. Revista Mirante (ISSN 1981-4089), 9(1), 35-45.

Guerra, M.S., Barbosa, M.S., Costa, E., Vieira, G.H.C. 2017. Recipiente biodegradável e substratos para mudas de maracujazeiro. Revista de Agricultura Neotropical, 4(3), 50-54. https://doi.org/10.32404/rean.v4i3.1641

He, X., Luan, F., Yang, Y., Wang, Z., Zhao, Z., Fang, J., Li, Y. 2020. *Passiflora edulis*: an insight into current researches on phytochemistry and pharmacology. Frontiers in pharmacology, 11, 617. https://doi.org/10.3389/fphar.2020.00617

IBGE. INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. 2025. Produção agrícola municipal: maracujá. http://www.ibge.gov.br (Acess in November 14, 2022).

INMET. INSTITUTO NACIONAL DE METEREOLOGIA DO BRASIL. 2024. Banco de Dados Meteorológicos. https://bdmep.inmet.gov.br/ (Acess in October 15, 2024).

Lessa, C.I.N., Sousa, G.G.D., Sousa, H.C., Lacerda, C.F.D., Silva, A.O.D., Guilherme, J.M.D.S. 2023. Morphophysiology of passion-fruit seedlings in different substrates under different strategies of irrigation with brackish water. Revista Ambiente & Água, 18, e2907. https://doi.org/10.4136/ambi-agua.2907

Lim, S.L., Wu, T.Y., Lim, P.N., Shak, K.P.Y. 2015. The use of vermicompost in organic farming: overview, effects on soil and economics. Journal of the Science of Food and Agriculture, 95(6), 1143-1156. https://doi.org/10.1002/jsfa.6849

Maguire, J. D. 1968. Seed dormancy, emergency and seedling vigor of some Kentucky bluegrass (*Poa pratensis* L.) varieties as affected by environmental and endogenous factors.

Matos, S., Costa, R.M., Sousa, R.C.M., Leite, M.R.L., Furtado, M.B., Farias, M.F., Serrano, L.J.P. 2020. Produtividade de quiabeiro sob influência de diferentes doses de esterco bovino. Revista Ibero-Americana de Ciências Ambientais, 11(7), 137-144. https://doi.org/10.6008/CBPC2179-6858.2020.007.0012

Nadai, F.B., Menezes, J.B.C., Catão, H.C.R.M., Advíncula, T., Costa, C.A. 2015. Produção de mudas de tomateiro em função de diferentes formas de propagação e substratos. Revista Agro@mbiente on-line-line, 9(3), 261-267. https://doi.org/10.18227/1982-8470ragro.v9i3.2348

Naumi, S.A., Wijaya, W., Wahyuni, S. 2024. The Effect of the Proportion of Vermicompost Fertilizer in Planting Media on the Growth of Papaya (*Carica papaya* L.) Calina Cultivar. Jurnal Agrosci, 1(3). https://doi.org/10.62885/agrosci.v1i3.178

Oliveira, R.R., Silva, D.F., Monzani, R.M. 2023. Avaliação da germinação das sementes de maracujá-amarelo (*Passiflora edulis*) submetida a diferentes métodos de superação de dormência. Agropecuária Catarinense, 36(3), 26-28. https://doi.org/10.52945/rac.v36i3.1720

Ramos, M., Rendin, E., Júnior, A,R.L. 2023. Panorama da produção de maracujá no Brasil, Minas Gerais e Unaí. Revista de la Facultad de Agronomía, 122. https://doi.org/10.24215/16699513e127

Ribeiro, A.A., Moreira, F.J.C., Seabra Filho, M., Menezes, A.S. 2016. Emergência do maracujazeiro-amarelo sob estresse salino em diferentes substratos. Revista Brasileira de Engenharia de Biossistemas, 10(1), 27-36. https://doi.org/10.18011/bioeng2016v10n1p27-36

Santos, C.C., Motta, I.S., Carneiro, L.F., Santos, M.C.S., Padovan, M.P., Mariani, A. 2014. Produção agroecológica de mudas de maracujá em substratos a base de húmus de minhoca e casca de arroz carbonizada. Cadernos de Agroecologia [Volumes 1 06 a 12 (2017)], 9(4).

Santos, C.C., Motta, I.S., Souza, J.P.C., Macedo, L.G.R., Posca, J.L.V., Carneiro, L.F. 2024. Vermicompost and Carbonized Rice Husk Influence the Production of Yellow Passion Fruit Cultivars Seedlings. Journal of Soil Science and Plant Nutrition, 24(3), 5360-5369. https://doi.org/10.1007/s42729-024-01912-9

Santos, C.V., Rodrigues, W.Z., Aparecido, C.F.F., Carvalho, J.B. 2020. Influência de misturas no desenvolvimento de mudas do maracujazeiro azedo. Unifunec científica multidisciplinar, 9(11), 1-12. https://doi.org/10.24980/rfcm.v9i11.3705

Santos, E.H.F., Silva, J.A.B., Guimarães, M.J.M., Meloni, D.A., Castro, J.L.G., Neves, A.V.F., Santos, A.S. 2022. Adubação orgânica como fator determinante de emergência e crescimento de mudas de maracujá-amarelo. Research, Society and Development,11(10). https://doi.org/10.33448/rsd-v11i10.32584

Santos, V.E., Neto, A.C.B., Mota, L.A., Oliveira, E.M., Paixão, M.V.S. 2023. Substratos minerais na emergência de plântulas de mamoeiro cv aliança. Revista foco, 16(02), e1216-e1216. https://doi.org/10.54751/revistafoco.v16n2-232

Silva, J.M., Silva, C.S., Alves, A.C., Amaral, T.S., Silva, A.A., Alves, E.S.A., Jesus, F.N. 2024. Produção de mudas de maracujá-amarelo em função de diferentes fertilizantes orgânicos e doses. Agropecuária científica no semiárido, 20(2), 14-19. https://doi.org/10.30969/xc3w6344

Silva, L.N., Lima, L.K.S., Aguiar, F.S., de Jesus, O.N. 2021. Cost reduction and quality enhancement in passion fruit seedlings using alternative substrate. Semina: Ciências Agrárias, 42 (3Supl1), 1549-1566. https://doi.org/10.5433/1679-0359.2021v42n3Supl1p1549

Schafer, G., Lerner, B.L. 2022. Physical and chemical characteristics and analysis of the plant substrate. Ornamental Horticulture, 28, 181-192. https://doi.org/10.1590/2447-536X.v28i2.2496

Silva, L.G.F., Sales, R.A., Rossini, F.P., Vitória, Y.T., Berilli, S.S. 2019. Emergência e desenvolvimento de plântulas de maracujá-amarelo em diferentes substratos. Energia na agricultura, 34(01), 18-27. https://doi.org/10.17224/EnergAgric.2019v34n01p18-27

Smolikova, G., Strygina, K., Krylova, E., Leonova, T., Frolov, A., Khlestkina, E., Medvedev, S. 2021. Transição de sementes para mudas: Aspectos hormonais e epigenéticos. Plantas, 10 (9), 1884.

Welter, M.K., Smiderle, O.J., Uchôa, S.C.P., Chang, M.T., Mendes, E.P. 2011. Germinação de sementes de maracujá amarelo azedo em função de tratamentos térmicos. Revista Agro@ mbiente On-line, 5(3), 227-232. https://doi.org/10.18227/1982-8470ragro.v5i3.626