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SCIENTIFIC ARTICLE

Sowing time and substrate in the production of ipê-mirim seedlings

Marcos Vieira Ferraz[1*], Antonio Maricélio Borges de Souza[1], Carla Rafaele Xavier Costa[1], Ana Carolina Corrêa Muniz[1], Eduardo Akira Suzuki de Andrade Loureiro[1], Kathia Fernandes Lopes Pivetta[1]

[1] Universidade Estadual Paulista (Unesp), Faculdade de Ciências Agrárias e Veterinárias (FCAV), Jaboticabal-SP, Brazil.

Abstract

Tecoma stans is popularly known as ipê-mirim in Brazil. This species belongs to the Bignoniaceae family and it is native to Americas and Antilles, where it is widely used in landscaping as urban tree. The seedlings are produced from seeds and there are several factors that influences its development, such as the sowing time and the substrate. This work aimed to understand the effect of the sowing time and substrates on the production of *Tecoma stans* seedlings. The experiments were carried out in a nursery. The experimental design was completely randomized. The substrates were arranged in a 2 × 6 factorial scheme, two sowing times (autumn and spring) and six commercial substrates (SC1; SC2; SC3; SC4; sand and vermiculite) under four replicates and ten seedlings per plot. The means were compared to each other using the Tukey test ($p < 0.05$). There was a significant difference between the seasons of the year, showing that the percentage of emergence was higher in spring (89%). The seedlings of *Tecoma stans* were shown to be nutrient-dependent both in the emergence of the seedling and in the subsequent development of the seedlings, since the highest averages of the studied characteristics were obtained in the commercial substrates, as they have nutrients in their composition, with greater emphasis on SC1.

Keywords: ornamental plant, seedling production, *Tecoma stans*, urban afforestation.

Resumo

Época de semeadura e substrato na produção de mudas de ipê-mirim

Tecoma stans, popularmente conhecida como ipê-mirim é uma espécie arbórea pertencente à Família Bignoniaceae. Nativa nas Américas e Antilhas, é amplamente utilizada no Brasil, no paisagismo e na arborização urbana. A produção de suas mudas é feita por sementes e são vários os fatores que interferem neste processo e no seu posterior desenvolvimento como a época de semeadura e o substrato. O objetivo deste trabalho foi avaliar o efeito da época de semeadura e do substrato na produção de mudas de *Tecoma stans*. Os experimentos foram conduzidos em viveiro. O delineamento experimental foi inteiramente casualizado. Os tratamentos foram arranjados em esquema fatorial 2 × 6 sendo duas épocas de semeadura (outono e primavera) e seis substratos (SC1; SC2; SC3; SC4; areia e vermiculita); foram quatro repetições e dez plântulas por parcela. Avaliou-se a porcentagem de emergência e variáveis morfológicas. As médias foram comparadas entre si por meio do teste de Tukey ($p < 0,05$). Verificou-se diferença significativa entre as épocas do ano mostrando que a porcentagem de emergência foi superior na primavera (89%). As mudas de *Tecoma stans* se mostraram ser dependentes de nutrientes tanto na emergência da plântula como no posterior desenvolvimento das mudas, já que estes possuem nutrientes em sua composição, com destaque superior para SC1.

Palavras-chave: arborização urbana, planta ornamental, produção de mudas, *Tecoma* stans.

Introduction

Tecoma stans (L.) Kunth (Bignoniaceae), is popularly known as ipê-mirim, and used in traditional medicine for the treatment of diabetes and digestive problems (Gonçalves et al., 2022), exhibited antitumor, antioxidant, antimicrobial, hypoglycemic, free radical anti-inflammatory, antimicrobial, anti-fungal and anti-diabetic properties (Abirami and Gomathi, 2022) but it is an ornamental plant (Larbie et al., 2020). The species is native to the Americas and Antilles; it is a medium-sized tree, measuring 4 to 6 meters in height and 25 cm in diameter at breast height (Lorenzi et al., 2003). According to the same authors, due to the exuberance of its yellowish flowers throughout the year, this species is one of the best ornamental elements for gardens and squares in Brazil, in all regions of the country, except where very severe frosts occur, as the species does not tolerate low temperatures. This plant is widely used as an ornamental tree in gardens, parks and in the urban environment (Castro and Montalvão, 2019). This species has been widely used

*Corresponding author: ferrazmarcos@yahoo.com.br

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in landscaping and even more in urban afforestation due to its size, which allows its use under aerial wiring.

Ipê-mirim is propagated by sexual mean and this multiplication process, as well as the later development of the seedling, are influenced by several factors, such as the sowing time and the substrate. The study of these factors is essential to produce lots without losses, in a short period of time, in addition to vigorous seedlings. Due to the variability in environmental conditions, it is essential to carry out studies regarding the sowing time for each location, since drought, heat and cold are abiotic stresses that interfere with germination (Jiménez-Alfaro et al., 2018).

The quality of the substrate is related to the presence of characteristics such as the absence of pathogens, richness in essential nutrients, texture, structure and adequate pH, in addition to easy acquisition and transport, water retention, porosity, available water, salinity and organic matter content (Silva et al., 2022). The substrate has the function of sustaining and providing adequate conditions for a seedling, contributing to its initial growth. Its composition is an influencing factor on the seedlings that will be offered on the market, providing the formation of seedlings with satisfactory quality, facilitating planting operations and ensuring good post-planting performance, greater entry into the field and resistance to environmental stresses (Siqueira et al., 2019).

In nurseries, the use of substrate poor in nutrients, or nutritionally unbalanced, is common, causing low quality of the seedlings, compromising their performance in the field, making it necessary to use mineral fertilization, especially of macronutrients, which are required in greater quantity by the plants (Silva et al., 2015). Ready-to-use substrates for seedling production can be found on the market and the main products sold are pine bark and peat based (Caldeira et al., 2011), however, it is difficult to find an isolated material that meets all the conditions necessary for different species, especially for forest species (Siqueira et al., 2018). In Brazil, it is also possible to observe that the production of seedlings, mainly in nurseries, is carried out using substrates made from different raw materials, prepared on site, which is often a problem for the nurserymen due to the time spent in preparation and the difficulty of to obtain a final substrate with desirable and uniform characteristics, especially when large volumes are needed.

Therefore, this work was conducted to evaluate the effect of sowing time and substrates on the production of seedlings of *Tecoma stans*.

Material and Methods

The experiment was carried out in a greenhouse covered with a black screen (sombrite®) such as screen that allows 50% of the light to pass through, in the state of São Paulo under the coordinates 21°15’2” latitude, 48°16’47” longitude and 600 meters of altitude. The region climate is subtropical *Cwa* type (humid tropical with dry winter and rainy summer) with minimum, average and maximum temperatures of 19.8 ºC, 24.5 ºC and 32.5 ºC, respectively.

The design of the experiment was factorial and completely randomized. The treatments were arranged in a 2 × 6 factorial scheme, with two sowing times (autumn and spring) and six substrates (Carolina Soil®; Basaplant®; Bioplant®; Maxfértil®; sand and expanded vermiculite of medium granulometry); there were four replications and 10 seeds per plot, sown individually in tubes containing the different substrates, four of them commercial with varied compositions, and they were named SC1, SC2, SC3 and SC4.

1. SC1 - peat, vermiculite, roasted rice husk, calcined dolomitic limestone, NPK 14-16-18 fertilizer and micronutrients.
2. SC2 - peat, vermiculite, pine bark, charcoal and correctives.
3. SC3 - vermiculite, pine bark, sawdust, coconut fiber, rice husk, ash, manure, agricultural gypsum, calcium carbonate, magnesium thermophosphate and fertilizers.
4. SC4 - Pinus husk, rock phosphate, carbonized rice husk, vermiculite and NPK fertilizer.

The substrates were purchased from local commerce, and their chemical and physical characteristics were obtained from existing data on the packaging, direct information from the manufacturers and analyzes carried out in the laboratory of the Instituto Agronômico de Campinas, SP (Table 1)

Table 1. Physical and chemical characteristics of commercial substrates used in the production of seedlings of *Tecoma stans* (L.) Juss. ex Kunth.

Chemical and physical properties	SC1	SC2	SC3	SC4
pH (H_2O)	5.5	5.5	5.5	5.5
CE (mS cm^{-1})	0.7	0.7	1.0	0.4
Umidity (%)	60.0	50.0	55.0	58.0
Dry density (kg m^{-3})	130.0	657.5	170.0	310.0
WRC (% v/v)	85.0	60.4	69.0	52.4
N (g Kg^{-1})	5.6	4.2	4.7	4.3
P (g Kg^{-1})	1.2	0.0021	2.5	2.3
K (g Kg^{-1})	11.1	0.0965	3.0	1.1
Ca (g Kg^{-1})	11.0	0.0369	8.5	11.4
Mg (g Kg^{-1})	44.3	0.0140	7.9	3.2
S (g Kg^{-1})	1.5	0.0479	1.4	0.6
B (mg Kg^{-1})	30.6	0.1293	36.4	36.1
Cu (mg Kg^{-1})	19.6	0.0274	15.4	37.2
Fe (g Kg^{-1})	17.6	0.0039	16.3	21.5
Mn (mg Kg^{-1})	222.6	0.8487	259.1	315.0
Zn (mg Kg^{-1})	35.7	0.0867	56.7	111.7

Extraction method: pH and electrical conductivity (EC) 1:5: method described in IN 17 of 21/05/2007; Humidity at 65ºC: methods described in IN 17 of 05/21/2007 and IN 31 of October 23, 2008; Dry density: methods described in IN 17 of 21/05/2007 and IN 31 of 23 October 2008. Water Retention Capacity (CRA 10): tension table at 10 cm of water column (10kPa). Methods described in IN 17 of 05/21/2007 and IN 31 of October 23, 2008.

The two experiments were installed in two different seasons (Autumn and spring). In autumn, the experiment was installed on 25/04/2018 and in spring, on 10/10/2018. Before sowing, the water content of the seeds was determined by the oven method at 105 ± 3 ºC, for 24 hours (Ista, 2017), using two replicates of 20 seeds. The water content obtained in the seeds in autumn was 8.26% and in spring 8.27%. Such determination was performed only to verify how the seeds were in relation to the water content at the time of sowing.

Sowing was carried out in tubes with a volumetric capacity of 100 mL, two seeds were placed and then thinned, leaving only one, adopting as criterion the seedling with greater vigor and more centralized. 10 tubes were used per plot. Irrigation was carried out through automatically activated micro-sprinklers, 12 times a day, at intervals of one hour, with the first irrigation at 6 hours and the last at 18 hours, with a duration of 5 minutes each irrigation.

Climatic data during the experiments were obtained from the meteorological station of UNESP/FCAV (Figure 1)

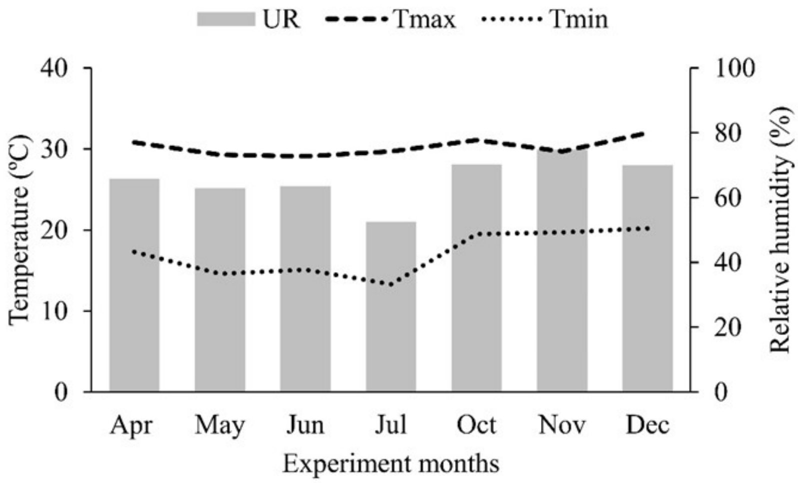

Figure 1. Data of maximum (Tmax) and minimum (Tmin) temperature in ºC, and relative humidity (%) obtained during the production of seedlings of *Tecoma stans* (L.) Juss. ex Kunth in the year 2018.

The evaluations were carried out when the seedling roots began to appear at the lower end of the tubes, on 04/07/18 (autumn) and 05/12/18 (spring); to calculate the percentage of emergence, the number of seedlings that developed in each plot was noted, according to Labouriau (1983). Subsequently, the following parameters were randomly evaluated in five seedlings per plot: a) Length of the aerial part, determined from the level of the substrate to the apex of the last leaf, using a ruler in cm; b) Stem diameter in mm, measured at the height of the seedling neck, using a digital caliper; c) Counting the number of fully expanded sheets; d) Leaf area, using an electronic leaf area meter (Li-3100C, LI-COR®, Lincoln, Nebraska, USA); e) Dry mass of the aerial part, in grams; f) Dry mass of the root system, in grams; and g) Total dry mass in grams, obtained by summing the dry mass of the aerial part and the dry mass of the root system.

To determine the leaf area and dry mass of the aerial part and root system, the seedlings were removed from the tubes and their roots were washed to remove the substrate and, after washing, the seedlings were sectioned using a scissors, separating the aerial part of the root system. The leaf area was read and then the aerial part and roots were placed separately in paper bags and placed to dry in an oven with forced air circulation, at 70 ºC until reaching constant weight, being subsequently weighed in precision scale (0.001g) (SHIMADZU®, model AY220).

The collected data were subjected to analysis of variance. For statistical analysis purposes, the emergence percentage data were previously transformed into arcsine $(x/100)^{1/2}$. The means, when significant, were compared to each other using the Tukey test at 5% probability. It was used the AgroEstat® statistical software (Barbosa and Maldonado Júnior, 2015).

Results and Discussion

For emergence percentages of *Tecoma stans* seedlings, the interaction between time of year and substrates was not significant. There was a significant difference between the seasons of the year showing that the percentage of emergence was higher in spring. There was also a statistical difference between the substrates; SC1 and SC2 had higher means, not differing, however, from SC3 and SC4. Emergence was lower in substrates considered inert, showing that this species is nutrient-dependent in the initial phase of seedling development (Table 2)

Table 2. Percentage of emergence (%) of seedlings of *Tecoma stans* (L.) Juss. ex Kunth produced in two seasons (autumn and spring) and six substrates (SC1, SC2, SC3, SC4, sand and vermiculite)

Season	
Autumn	Spring
81.7 b	89.2 a

Substrates					
SC1	SC2	SC3	SC4	Sand	Vermiculite
92.5 a	92.5 a	88.8 ab	83.8 abc	75.0 c	80.0 bc

Means followed by the same letter on the line do not differ by Tukey's test at 5% probability.

The initial development time of the seedlings, from sowing to the appearance of the roots at the lower end of the tubes, was different in the two periods evaluated, with the roots starting to appear in autumn at 70 days and in spring, at 56 days after sowing. It should be noted that no statistical analysis was performed for the period of appearance of the roots and this was only demonstrative of the difference between the times for the evaluation of the seedlings. It is possible to infer, therefore, that *T. stans* seedlings sown in spring showed a higher percentage of emergence and developed faster when compared to seedlings in autumn.

This difference can be explained by the fact that temperature and humidity were higher in spring (Figure 1). On the other hand, at lower temperatures, there is a decrease in the speed of imbibition and mobilization of reserves, causing a significant decrease in the speed of germination (Marcos-Filho, 2015). Similarly, seeds of other tree species such as *Caesalpinia pulcherrima* (Araújo Neto et al., 2014), *Psidium friedrichsthalianum* (O. Berg) Nied. (Gentil et al., 2018), *Albizia niopoides* Benth. (Silva et al., 2018) and *Campomanesia guazumifolia* (Cambess.) O. Berg. (Souza et al., 2018), also germinated faster at higher temperatures.

Furthermore, a good substrate must provide good water retention to condition seed imbibition and aeration for oxygen diffusion (Ferraz et al., 2018) because excess moisture in the substrate promotes a decrease in germination by providing less oxygen, making respiration difficult and reducing metabolic processes (Sá et al., 2017), which can affect the percentage of emerged seedlings. However, it should be noted that each plant species has a different water requirement for its growth in nurseries, due to its morphological characteristics and adaptation to environments (Dresch et al., 2016; Mota et al., 2017). For the forest species *Bauhinia scandens* L., when the mean emergence time was evaluated, the vermiculite and commercial substrates provided a significant effect in relation to the tested wetting, with a decrease in the emergence time as there was an increase in water availability (Jeromini et al., 2021). Thus, it is clear that plants will respond differently to each growing condition, especially with regard to growth, quality and metabolism (Dresch et al., 2016).

For all qualitative characteristics evaluated (shoot length, stem diameter, number of leaves, leaf area, shoot dry mass, root and total dry mass) the interaction between sowing time and substrates was significant. There was no clear trend in relation to the season, since higher means were observed in both autumn and spring for the different characteristics (Table 3), showing that the sowing time was not a factor that influenced the production of *T. stans* seedlings.

Table 3. Means of seedling characteristics of *Tecoma stans* (L.) Juss. ex Kunth produced in two seasons (autumn – O and spring – P) and six commercial substrates.

	SC1	SC2	SC3	SC4	Sand	Vermiculite
			Lenght of aerial part (cm)			
O	6.13 A a	3.33 B b	5.57 A a	2.42 B c	1.50 B d	1.97 B cd
P	5.99 A a	3.90 A b	5.40 A a	3.10 A c	3.14 A c	2.55 A c
			Stem diameter (mm)			
O	2.07 A a	1.42 A bc	1.68 A b	1.03 A de	0.82 B e	1.13 A cd
P	0.97 B a	1.16 B a	1.15 B a	1.09 A a	1.05 A a	0.88 B a
			Number of leaves			
O	6.05 A a	4.05 A b	6.50 A a	4.20 A b	2.45 B c	2.50 A c
P	5.67 A a	4.83 A ab	6.00 A a	3.42 A bc	3.84 A bc	2.67 A c
			Leaf area (cm²)			
O	10.59 B a	2.75 A b	11.60 A a	2.17 A b	0.65 A b	0.77 A b
P	13.53 A a	4.43 A bc	7.15 B b	2.10 A c	2.87 A c	1.52 A c
			Dry mass of aerial part (g)			
O	0.103 A a	0.036 B c	0.068 A b	0.019 B c	0.013 B c	0.017 B c
P	0.077 B a	0.057 A abc	0.070 A ab	0.037 A c	0.049 A bc	0.035 A c
			Root dry mass (g)			
O	0.094 A a	0.035 A bc	0.051 A b	0.022 A c	0.014 B c	0.017 A c
P	0.063 B a	0.041 A ab	0.034 B b	0.030 A b	0.045 A ab	0.025 A b
			Total dry mass (g)			
O	0.197 A a	0.071 B c	0.121 A b	0.041 B cd	0.027 B d	0.034 B d
P	0.140 B a	0.098 A bc	0.104 A b	0.068 A cd	0.094 A bcd	0.060 A d

Means followed by the same uppercase letter in the column and lowercase letter in the row do not differ by Tukey's test at 5% probability.

However, it should be noted that plants change their morphology according to soil and climatic conditions, and as there is an increase in solar radiation, the greater the rate of emission and expansion of leaves and, consequently, the greater the leaf area index, increasing the leaf efficiency in converting photosynthetically active radiation into phytomass (Schwerz et al., 2019).

Related to the substrates, it is observed that SC1 was the one with the highest means for most of the qualitative and quantitative characteristics and in the two periods studied (Tables 2 and 3). The success of the SC1 substrate in relation to other potential substrates is due to its formulation, as it contains Canadian peat, also known as peat moss or sphagnum peat. The availability of water in the substrate is a fundamental part of the processes of root and leaf emission, as well as the transport of water and nutrients via the xylem, providing conditions for the production of photoassimilates necessary for the growth and initial development of the seedling (Masiero et al., 2019). The function of the substrate is to provide adequate conditions for the development and growth of the plant root system (Aimi et al., 2019)

T. stans proved to be nutrient dependent both in the initial phase of seedling emergence and in the subsequent development of the seedlings, as the highest averages of morphological characteristics were obtained in enriched substrates, mainly SC1, and the lowest averages in sand and vermiculite, substrates considered inert (Table 3). The substrate composition can change emergence, initial growth and the content of photosynthetic pigments, modifying the capture of radiant energy and influencing the amount of assimilates produced (Afonso et al., 2017).

In this regard, it is reported by Taiz et al. (2017) that the N and Mg^{++} are constituents of the chlorophyll molecule, responsible for the photosynthesis that the plant performs, as well as the production of photoassimilates, thus favoring plant height growth, as well as acting directly with the increase in leaf area. In this way, plants that have a high concentration of chlorophyll are potentially able to reach higher photosynthetic rates, and consequently better adaptation during the field planting phase (Afonso et al., 2017).

Furthermore, it can be seen that the seedlings produced in the SC1 substrate made more efficient use of existing nutrients and water, as there was a greater increase in total dry mass, especially in the seedlings produced in autumn (Table 3). The same fact was observed for the species *Plukenetia volubilis* (Jeromini et al., 2018) and *Bauhinia scandens* (Jeromini et al., 2021), in which the use of nutritionally enriched commercial substrates were responsible for the maximum development of the already emerged seedlings.

The pH, electrical conductivity and physical characteristics were not very different among the substrates used (Table 1), except for the high density of the SC2 substrate (657.5 kg m^{-3}). Substrate pH directly affects nutrient mobility and availability (Pascual et al., 2018) and, when outside the ideal range for a species, it can be the main determinant of seedling quality (Gabira et al., 2020). Electrical conductivity, on the other hand, refers to an indication of the concentration of salts in the solution and provides a parameter for estimating the amount of nutrients present in the substrates (Pêgo et al., 2019) and, according to Gabira et al. (2020), high values can negatively affect plant root growth, significantly influencing seedling quality.

Aimi et al. (2019) emphasize that the physical condition is important because the substrate must be porous, thus avoiding the lack of oxygen, and water availability to the roots. Sand presents high and vermiculite with low density (Kämpf, 2000), being verified for sand a density of 1333 kg m^{-3} and for vermiculite, 159 kg m^{-3} (Stumpf et al., 1999). However, Fermino and Kämpf (2012) report that vermiculite is a widely used substrate because its physical characteristics such as porosity, aeration and water retention are favorable to root development. Garcia et al. (2011) based on other literature, commented that the ideal dry density for vegetable growing substrates is between 400 to 500 kg m^{-3}, therefore, this characteristic may have been one of the reasons that affected the development of *T. stans* seedlings mostly in the sand, because the commercial substrates, with the exception of SC2, presented density values below the proposed in the literature.

High density materials, such as sand and soil, when used alone or in large proportions in the formulation of a substrate, become inconvenient due to their excessive weight, which makes it difficult to handle the plants in the containers, reducing the penetration and growth of the plants roots (Costa et al., 2017). On the other hand, the same authors report that low porosity materials can cause root gas exchange, water movement and drainage problems, negatively affecting root and plant development, unlike mixtures of higher porosity, which can be beneficial for aeration and promotion of root development. In this sense, choosing the appropriate substrate is a key factor when planting the crop, as its characteristics generally differ greatly from those of the soil (Soldateli et al., 2020).

The water retention capacity of the SC1, SC2 and SC3 substrates was equal to or above 60%, and the SC1 substrate, which presented the best performance in the production of *T. stans* seedlings, was 85%; these values are much higher than those indicated by Verdonck et al. (1981), who consider 50% of the substrate volume as the most adequate; only the SC4 substrate presented values close to this. Thus, this species showed that it is not directly affected by this feature.

Conclusions

Tecoma stans seedlings showed a higher percentage of emergence (89%) in the spring. Higher percentage of emergence and vigor were obtained in the commercial substrate one (SC1 - peat, vermiculite, roasted rice husk, calcined dolomitic limestone, NPK 14-16-18 fertilizer and micronutrients).

Author Contribution

MVF: conceptualization, data curation, formal analysis, investigation, methodology, software, visualization, writing-review and editing and translation. **AMBS:** conceptualization, data curation, formal analysis, investigation, methodology, software, visualization and writing-original draft. **CRXC:** conceptualization, data curation, formal analysis, investigation, methodology, software, visualization and writing-original draft. **ACCM:** conceptualization, data curation, formal analysis, investigation, methodology, software, visualization and writing-original draft. **EASAL:** conceptualization, data curation, formal analysis, investigation, methodology, software, visualization and writing-original draft. **KFLP:** funding acquisition, methodology, project administration, resources, supervision, validation and writing-review and editing.

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References

ABIRAMI, D.; GOMATHI, R. Target and candidate agents for diabetes treatment in the framework of the food nexus. **Energy Nexus**, v.5, n.16, 100041, 2022. https://doi.org/10.1016/j.nexus.2022.100041

AFONSO, M.V.; MARTINAZZO, E.G.; AUMONDE, T.Z.; VILLELA, F.A. parâmetros fisiológicos de mudas de *Albizia niopoides* produzidas em diferentes composições de substrato. **Ciência Florestal**, v.27, n.4, p.1395-1402, 2017.

AIMI, S.C.; ARAUJO, M.M.; FERMINO, M.H.; TABALDI, L.A.; ZAVISTANOVICZ, T.C.; MIETH, P. substrate and fertilization in the quality of *Myrocarpus frondosus* seedlings. **Floresta**, v.49, n.4, p.831-840, 2019. https://doi.org/10.5380/rf.v49 i4.59748

ARAÚJO NETO, J.C.; CAMARA, C.A.; FERREIRA, V.M.; LESSA, B.F.T.; OLIVEIRA, Y.M.O. Caracterização morfométrica, germinação e conservação de sementes de *Caesalpinia pulcherrima* (L.) Sw. (Fabaceae: Caesalpinioidea). **Semina: Ciências Agrárias**, v.35, n.4, p.2287-99, 2014. https://doi.org/10.5433/1679-0359.2014v35n4Suplp2287

BARBOSA, J.C.; MALDONADO JÚNIOR, W. **Experimentação Agronômica & AgroEstat; Sistema para Análises Estatísticas de Ensaios Agronômicos**. Jaboticabal: Gráfica Multipress, 2015. 396p.

CALDEIRA, M.V.W.; WENDLING, I.; PENCHEL, R.M.; GONÇALVES, E.O.; KRATZ, D.; TRAZZI, P.A. Propriedades de substratos para produção de mudas florestais. In: CALDEIRA, M.V.W.; GARCIA, G.O.; GONÇALVES, E.O.; ARANTES, M.D.C.; FIEDLER, N.C. (Eds.) **Contexto e Perspectivas da Área Florestal no Brasil**. Porto Alegre: Suprema, 2011. p.141-160.

CASTRO, M.T.; MONTALVÃO, S.C.L. Infestação da cigarrinha *Aetalion reticulatum* (hemiptera: aetalionidae) em plantas de amarelinho (*Tecoma stans*) em Brasília, Brasil. **Revista Científica Eletrônica de Engenharia Florestal da FAEF**. v.33, n.1, p.28-34, 2019.

COSTA, J.C.F.; MENDONÇA, R.M.N.; FERNANDES, L.F.; OLIVEIRA, F.P.; SANTOS, D. Caracterização física de substratos orgânicos para o enraizamento de estacas de goiabeira. **Revista Brasileira de Agropecuária Sustentável**, v.7, n.2, p.90-96, 2017. http://dx.doi.org/10.21206/rbas.v7i2.390

DRESCH, D.M.; SCALON, S.P.Q.; MUSSURY, R.M.; KODAMA, F.M. Initial growth of *Campomanesia adamantium* (Cambess.) O. Berg. seedlings on substrates with different compositions and water retention capacities. **Bioscience Journal**, v.32, n.1, p.1-10, 2016.

FERMINO, M.H.; KÄMPF, A.N. Densidade de substratos dependendo dos métodos de análise e níveis de umidade. **Horticultura Brasileira**, v.30, n.1, p.75-79, 2012. https://doi.org/10.1590/S0102-05362012000100013

FERRAZ, Y.T.; ALVES, J.D.N.; MOTA, F.F.A.; MONFORT, L.E.F.; OKUMURA, R.S. Emergência de sementes de arruda (*Ruta graveolens* L.) em diferentes substratos e profundidades de semeadura. **Nucleus**, v.15, n.1, p.1-8, 2018. http://dx.doi.org/10.3738/ 10.3738/1982.2278.1731.

GABIRA, M.M.; GOMES, J.F.P.; KRATZ, D.; WENDLING, I.; STUEPP, C.A. Industrial residues as substrate components for the production of *Ilex paraguariensis* seedlings. **Comunicata Scientiae**, v.11, e3215, 2020. https://doi.org/10.14295/CS.v11i0.3215

GARCIA, V.A.; MODOLO, V.A.; LAGÔA, A.M.M.A.; NOMURA, E.S.; SÁES, L.A. Características do resíduo de mineração de areia como componente de substratos para a produção de mudas de pupunheira (*Bactris gasipaes* Kunth). **Revista Árvore**, v.35, n.3, p.595-604, 2011.

GENTIL, D.F.O.; FERREIRA, S.A.N.; REBOUÇAS, E.R. Germination of *Psidium friedrichsthalianum* (O. Berg) Nied. seeds under different temperature and storage conditions. **Journal of Seed Science**, v.40, n.3, p.246-52, 2018. https://doi.org/10.1590/2317-1545v40n3179617

GONÇALVES, T.P.R.; PARREIRA, A.G.; ZANUNCIO, V.S.S.; FARIAS, K.S.; SILVA, D.B.; LIMA, L.A.R. Antibacterial and antioxidant properties of flowers from *Tecoma stans* (L.) Juss. ex Kunth (Bignoniaceae). **South African Journal of Botany**, v.144, p.156-165, 2022. https://doi.org/10.1016/j.sajb.2021.08.028

Ista. **International Rules for Seed Testing**. Bassersdorf: International Seed Testing Association, 2017. 296p.

JEROMINI, T.S.; BARBOSA, A.S.V.; SILVA, G.Z.; MARTINS, C.C. Substrate and seed sowing position on the production of *Plukenetia volubilis* L. seedlings. **Revista Brasileira de Engenharia Agrícola e Ambiental**, v.22, n.6, p.396-400, 2018. http://dx.doi.org/10.1590/1807-1929/agriambi.v22n6p396-400

JEROMINI, T.S.; SILVA, G.Z.; MARTINS, C.C.; NEVES, B.R. Water availability and substrate in the emergency and initial development of *Bauhinia scandens* L. **Revista Ceres**, v.68, n.2, p.143-148, 2021. https://doi.org/10.1590/0034-737X202168020008

JIMÉNEZ-ALFARO, B.; HERNÁNDEZ-GONZÁLEZ, M.; FERNÁNDEZ-PASCUAL, E.; TOOROP, P.; FRISCHIE, S.; GÁLVEZ-RAMÍREZ, C. Germination ecology of winter annual grasses in Mediterranean climates: Applications for soil cover in olive groves. **Agriculture, Ecosystems & Environment**, v.262, p.29-35, 2018. https://doi.org/10.1016/j.agee.2018.04.013

KÄMPF, A.N. Seleção de materiais para uso como substrato. In: KÄMPF, N.A.; FERMINO, M.H. (Eds.) **Substratos para plantas: a base da produção vegetal em recipientes**. Porto Alegre: Gênesis, 2000. p.139-145.

LABOURIAU, L.G. **A germinação das sementes**. Washington: Secretaria da OEA, 1983. 173p.

LARBIE, C.; EMIKPE, B.O.; AKPOR, S.A.; ADAMS, E.; ADJEI, C.O.; OYAGBEMI, A.A.; JARIKRE, T.A. Ameliorative effect of extract of *Tecoma stans* (L.) Juss. ex kunth leaves against CCl_4 - and acetaminophen induced liver damage in rats. **Advances in Traditional Medicine**, v.20**,** p.555-562, 2020. https://doi.org/10.1007/s13596-020-00465-3

LORENZI, H.; SOUZA, H.M.; TORRES, M.A.V.; BACHER, L.B. **Árvores exóticas no Brasil: madeiras, ornamentais e aromáticas**. 1.ed. Nova Odessa: Instituto Plantarum, v.1, 2003. 368p.

MARCOS-FILHO J. **Fisiologia de sementes de plantas cultivadas**. Londrina: ABRATES, 2015. 660p.

MASIERO, M.A.; ORIVES, K.G.R.; CRUZ, L.C.; AMÂNCIO, J.S.; FELICETI, M.L.; VIANA, C.M.S.S.; LIMA, D.M. Uso de substratos na estaquia de astrapeia (*Dombeya wallichii* L.). **Cultura Agronômica**, v.28, n.3, p.241-253, 2019. http://dx.doi.org/10.32929/2446-8355.2019v28n3p241-253

MOTA, L.H.S.; SCALON, S.P.Q.; HEINZ, R.; DRESCH, D.M. Substrates and water availability on the emergence and initial growth of *Alibertia sessilisschum* seedlings. **Floresta**, v.47, n.4, p.512-522, 2017. http://dx.doi.org/10.5380/rf.v47i4.53083

PASCUAL, J.A.; CEGLIE, F.; TUZEL, Y.; KOLLER, M.; KOREN, A.; HITCHINGS, R.; TITTARELLO, F. Organic substrate for transplant production in organic nurseries. A review. **Agronomy for Sustainable Development**, v.38, n.35, p.1-23, 2018. https://doi.org/10.1007/s13593-018-0508-4

PÊGO, R.G.; ANTUNES, L.F.S.; SILVA, A.R.C. Vigor of zinnia seedlings produced in alternative substrate in trays with different cell size. **Ornamental Horticulture**, v.25, n.4, p.417-424, 2019. https://doi.org/10.1590/2447-536X.v25i4.2049

SÁ, F.V.D.S.; MESQUITA, E.F.; SOUZA, F.M.; MESQUITA, S.D.O.; PAIVA, E.P.; SILVA, A.M. Depleção de água e composição do substrato na produção de mudas de melancia. **Revista Brasileira de Agricultura Irrigada**, v.11, n.3, p.1398-1406, 2017. https://doi.org/10.7127/rbai.v11n300550

SCHWERZ, F.; ELOY, E.; ELLI, E.F.; CARON, B.O.; PAULA, G.M. Temperatura e radiação solar na produção de mudas de cedro australiano. **Scientia Forestalis**, v.47, n.124, p.733-743, 2019. https://doi.org/10.18671/scifor.v47n124.15

SILVA, E.D.; MATOS, H.R.R; BARROS, B.G.A.; OLIVEIRA, F.J.V. Goat manure in the composition of substrates for germination and emergency of *Lablab purpureus*. **Scientific Electronic Archives**, v.15. n.1, p.13-20, 2022. https://doi.org/10.36560/15120221505

SILVA, F.A.M.; SOUZA, I.V.; ZANON, J.A.; NUNES, G.N.; SILVA, R.B.; FERRARI, S. Produção de mudas de juçara com resíduos agroindustriais e lodo de esgoto compostados. **Brazilian Journal of Biosystems Engineering**, v.9, n.2, p.109-121, 2015. https://doi.org/10.18011/bioeng2015v9n2p109-121

SILVA, D.Y.B.; SILVA, A.M.P.; FARIAS, S.G.G.; SILVA, R.B.; MATOS, V.P.; SILVA, L.S. Substrate and temperature on germination and performance of *Albizia niopoides* Benth. seedlings. **Ciência Rural**, v.48, n.3, p.1-7, 2018. https://doi.org/10.1590/0103-8478cr20161043

SIQUEIRA, D.P.; CARVALHO, G.C.M.W.; BARROSO, D.G.; MARCIANO, C.R. lodo de esgoto tratado na composição de substrato para produção de mudas de *Lafoensia glyptocarpa*. **Floresta**, v.48, n.2, p.277-284, 2018. https://doi.org/10.5380/rf.v48i2.55795

SIQUEIRA, D.P.; BARROSO, D.G.; CARVALHO, G.C.M.W.; ERTHAL, R.M.; RODRIGUES, M.C.C.; MARCIANO, C.R. Lodo de esgoto tratado na composição de substrato para produção de mudas de *Plathymenia reticulata* Benth. **Ciência Florestal**, v.29, n.2, p.728-739, 2019. https://doi.org/10.5902/1980509827297

SOLDATELI, F.J.; BATISTA, C.B.; GODOY, F.; MELLO, A.C.; SOARES, F.S.; BERGMANN, M.D.; ETHUR, L.Z. Crescimento e produtividade de cultivares de tomate cereja utilizando substratos de base ecológica. **Colloquium Agrariae**, v.16, n.1, p.1-10, 2020. https://doi.org/10.5747/ca.2020.v16.n1.a342

SOUZA, M.T.; SOUZA, M.T.; PANOBIANCO, M. Morphological characterization of fruit, seed and seedling, and seed germination test of *Campomanesia guazumifolia*. **Journal of Seed Science**, v.40, n.1, p.75-81, 2018. https://doi.org/10.1590/2317-1545v40n1186143

STUMPF, E.R.T.; GROLLI, P.R.; SILVA, J.A.G. Enraizamento de estacas de *Chamaecyparis lawsoniana* Parl. em cinco substratos com uso de ácido indolbutírico. **Ciência Rural**, v.29, n.2, p.207-211, 1999. https://doi.org/10.1590/S0103-84781999000200004

TAIZ, L.; ZEIGER, E.; MOLLER, I.M.; MURPHY, A. **Fisiologia e desenvolvimento vegetal**. Porto Alegre: Artmed Editora, 2017. 858p.

VERDONCK, O.; VLEESCHAUWER, D.; BOODT, M. The influence of the substrate to plant growing medium for plants. **Acta Horticulturae**, v.126, p.251-258, 1981. https://doi.org/10.17660/ActaHortic.1982.126.30