DOI: 10.5433/1679-0359.2018v39n6p2851

Substrates for the cultivation of epiphytic orchids

Substratos para o cultivo de orquídeas epífitas

Ricardo Tadeu de Faria[1]; Vanessa Stegani[2]; Douglas Junior Bertoncelli[3*]; Guilherme Augusto Cito Alves[4]; Adriane Marinho de Assis[5]

Abstract

Orchids are among the most commercialized flowers in the market of potted plants, cut flowers, and landscaping, making necessary studies that allow the optimization of its cultivation. One of the most important aspects for success in production areas is the use of quality seedlings, which requires the use of an appropriate substrate with appropriate physical, chemical, and biological properties to the species. Thus, this review aimed to report the importance and diversity of substrates used for producing epiphytic orchids. Several substrates have been studied for the cultivation of epiphytic orchids, among which can be cited coconut fiber and powder, pine bark, coffee husk, carbonized rice husk, almond bark, sugarcane bagasse, charcoal, vermiculite, S-10 Beifort®, among others, which provided satisfactory results in the production of seedlings and development of orchid plants. Studies with the substrates are directed to the ecologically correct cultivation and the rational use of agroindustrial residues available in each region in order to reduce their volume in the environment, in addition to allowing the adequacy in production costs.

Key words: Pot cultivation. Orchidaceae. Seedling production.

Resumo

As orquídeas estão entre as flores mais comercializadas no mercado de planta de vaso, flor de corte e paisagismo, tornando-se necessários estudos que permitam a otimização do seu cultivo. Um dos aspectos primordiais para o sucesso nas áreas de produção é a utilização de mudas de qualidade, que por sua vez, demanda o uso do substrato adequado, com propriedades físicas, químicas e biológicas adequadas à espécie em questão. Assim, essa revisão objetivou reportar a importância e a diversidade dos substratos utilizados para a produção de orquídeas epífitas. Vários substratos vêm sendo estudados no cultivo de orquídeas epífitas, entre os quais podem ser citados a fibra e o pó de coco, a casca de pinus, a casca de café, a casca de arroz carbonizada, a casca de amendoeira, o bagaço de cana-de-açúcar, o carvão vegetal, a vermiculita, o S-10 Beifort®, entre outros, os quais propiciaram resultados satisfatórios na produção de mudas bem como no desenvolvimento das plantas de orquídeas. Os estudos com os substratos estão voltados ao cultivo ecologicamente correto e ao aproveitamento racional de resíduos da agroindústria disponíveis em cada região, de modo a reduzir o volume desses materiais no meio ambiente, além de possibilitar a adequação nos custos de produção.

Palavras-chave: Cultivo em vaso. Orchidaceae. Produção de mudas.

[1] Prof. Dr., Departamento de Agronomia, Universidade Estadual de Londrina, UEL, Londrina, PR, Brasil. E-mail: faria@uel.edu.br
[2] Profª, Instituto Federal do Paraná, Campus Ivaiporã, IFPR, Ivaiporã, PR, Brasil. E-mail: vanessa.stegani@ifpr.edu.br
[3] Dr. em Agronomia, UEL, Londrina, PR, Brasil. E-mail: dj_bertoncelli@hotmail.com
[4] Discente de Doutorado em Agronomia, UEL, Londrina, PR, Brasil. E-mail:guilhermecito@hotmail.com
[5] Profª, Universidade Federal de Pelotas, UFPEL, Pelotas, RS, Brasil. E-mail: agroadri17@gmail.com
[*] Author for correspondence

Received: Oct. 02, 2017 - Approved: Sept. 05, 2018

Introduction

The Orchidaceae family is considered one of the largest within the angiosperms, with approximately 35,000 species distributed in more than 1,000 genera, most of them epiphytic. It has approximately 120,000 hybrids, obtained through interspecific and/or intergeneric crosses, with a high variability of shapes, sizes, and colors (RUSCHI, 1997; FARIA et al., 2010; VENDRAME et al., 2014).

Orchid production is a growing activity in the domestic and international markets, with ecological and economic importance. Its cultivation is focused, in a large part, on the florist market, but also presents an interest in other economic sectors such as cosmetics, pharmaceutical, and food industries (SEQUEIRA, 2007).

In commercial orchid cultivation, the use of a substrate is essential since it influences the quality of the final product, mainly performing the function of support to the root system. It may be composed of a single material or the mixing of two or more materials. Therefore, the evaluation of physical, chemical, and biological properties when choosing a substrate is of paramount importance.

The material selected as substrate should contain desirable characteristics regarding the capacity of aeration and retention of water and nutrients, adequate pH, and consistency to support the root system in order to provide satisfactory conditions for plant growth and development. This material should also be easy to handle and availability, low cost, long durability, and free from pathogens (KÄMPF, 2000; FERNANDES et al., 2006; YAMAKAMI et al., 2006; ASSIS et al., 2008; FARIA et al., 2010).

Historically, the most used materials for the cultivation of epiphytic orchids in Brazil have been the xaxim and sphagnum, but due to the deregulated extraction, these products are no longer used in large scale. Through the approval of the bill No. 11,754/2004, the industrialization and commercialization of products and artifacts from the extraction of *Dicksonia sellowiana* in the State of São Paulo were prohibited either directly or indirectly.

The use of alternative substrates for orchid cultivation is essential because it avoids the illegal extraction of endangered species and contributes to the use of agroindustrial residues available in the region, which minimize their accumulation in the environment and reduce investments in treatments to control pollution (LIMA et al., 2007; PELIZER et al., 2007).

Several sources of material can be used in the cultivation of epiphytic orchids, some of which of plant origin, such as coconut fiber, coconut powder (ASSIS et al., 2005, 2008), carbonized rice husk (ARAUJO et al., 2007; YAMAKAMI et al., 2009; SORACE et al., 2009), pine bark (YAMAKAMI et al., 2006; MULLER et al., 2007; LONE et al., 2008), coffee husk (ASSIS et al., 2011; MORA et al., 2015), almond seeds (SANTOS; TEIXEIRA, 2010), among others, others of mineral origin, such as vermiculite (REGO et al., 2000; FARIA et al., 2001), expanded clay, and gravel, and even synthetic materials, such as styrofoam (CORRÊA et al., 2000; MORAES et al., 2002) and phenolic foam, which have been tested in isolation or in association with other materials and have provided satisfactory results in the development of epiphytic orchids.

In this context, this review aims to report the diversity and importance of substrate in the cultivation of epiphytic orchids.

The Orchids

Orchids are present around most of the world, except for desert regions, poles, and ice zones. According to the place of origin, orchids are classified as epiphytic, terrestrial, rupicolous, or saprophytic (WATANABE et al., 2002; FARIA et al., 2010).

Epiphytic orchids represent most of the species of the family Orchidaceae. These plants live mainly on trees, where they receive light filtered through the canopy and aeration in abundance, as well as nutrients absorbed from the material in decay around them and rainwater. They are not parasites since they use the trunk of other plants only for fixation.

Due to these aspects, the roots of epiphytic orchids have the function of fixing the plant to the support and supplying water and nutrients. They usually present a whitish-looking epidermal cell lining called velamen (SHIRAKI; DIAS, 2012). Some examples of plants belonging to this group are those of the genus *Brassavola*, *Cattleya*, *Dendrobium*, *Miltonia*, *Oncidium*, and *Phalaenopsis*, which are among the most cultivated plants, both in Brazil and in other countries.

In the case of terrestrial species, these live directly on the soil, taking water and nutrients out of it. If compared to the epiphytic, the number of terrestrial species is very small. Some of the most cultivated are *Arundina*, *Bletia*, *Cymbidium*, *Neobenthamia*, *Phaius*, and *Paphiopedilum* (WATANABE et al., 2002).

The orchids that live in nature on rocks or cliffs are rupicolous. These plants extend their roots through the surface of rocks or penetrate the cracks and irregularities where nutrients and water they need for their development are accumulated. As examples, the genera *Epidendrum*, *Hoffmannseggella*, and *Bifrenaria* can be cited (SHIRAKI; DIAS, 2012).

Other orchid species, the saprophytes, are devoid of chlorophyll and feed on decomposing plant remains, such as *Rhizanthella gardneri* (FARIA et al., 2010).

In addition to their growing habitat, orchids can be grouped, according to the type of growth, into sympodial and monopodial. Sympodial orchids have lateral growth, for example, the genera *Cattleya*, *Laelia*, *Miltonia*, and *Oncidium*. On the other hand, monopodial orchids show unlimited apical growth, i.e. they grow vertically from a central stem that produces alternating leaves and inflorescence between them. Plants of the genera *Vanda*, *Vanilla*, and *Phalaenopsis* may be cited as examples (FARIA et al., 2010).

Other relevant information regarding the family Orchidaceae is related to the flower size. In order to be considered as mini orchids, they have to present flowers of 1.0 to 5.0 cm in diameter, while micro orchids have flowers of a size smaller than 1.0 cm in diameter.

Some examples of mini orchids include the genera *Sophronitis* and *Hadrolaelias*, among which *Laelia pumila* and *Laelia spectabilis* stand out. Among the micro orchids are those of the genus *Octomeria*, *Pleurothallis*, and *Stelis*.

The natural habitat of micro orchids is subtropical and tropical forests and the temperate zone (DEMATTÊ; DEMATTÊ, 1996). However, in general, these plants do not present a great ornamental appeal due to the reduced size of plants and their flowers, in addition to peculiarities in relation to the cultivation (MYERS et al., 2000).

Substrate

The substrate is the medium where the roots of plants grown outside the soil are developed, supporting them (KÄMPF, 2000). For seedling production and orchid cultivation, the use of a substrate is of paramount importance, influencing the quality of the final product (ASSIS et al., 2011). Therefore, the selection of the material to be used as substrate should take into account the species, physical and chemical characteristics, cost, and availability (FONSECA, 2001), as well as the ecological aspects, aiming to maximize the benefits they can provide to plant development (ASSIS et al., 2011).

Among the physical characteristics to be considered, density, porosity, and water retention capacity, which are related to gas exchange and shoot and root development, can be mentioned. According to Silva and Silva (1997), consistency, good aeration, and ability to retain water without waterlogging are essential because if an inadequate drainage occurs, plants can suffer stress and eventually die.

Regarding the chemical characteristics, pH influences nutrient availability. In the case of electrical conductivity, plants present different degrees of sensitivity to the content of soluble salts of the substrate, and orchids classified as sensitive tolerate salinity levels between 0.5 and 1.0 mS^{-1} cm^{-2} (KÄMPF, 2000). In addition to these characteristics, it is important to consider the structural stability and the material must be pathogen free. Table 1 shows the characteristics of the main substrates used in the cultivation of epiphytic orchids. Another requirement is related to substrate cost. Thus, availability in the region and ease of transportation are important. On the other hand, from an ecological point of view, it must be extracted from agricultural or industrial residues in order to minimize their environmental impact (ROSA et al., 2001). Because of these aspects, finding a material that alone meets all of these requirements, in addition to the needs of the plant to be cultivated, is not an easy task. Thus, seedling producers end up using mixtures of materials in order to gather as many desirable characteristics as possible and decrease production costs (SANTOS et al., 2000).

Table 1. Species of orchids and substrates most suitable for cultivation.

Species	Substrate	Proportion	Reference
Brassocattleya pastoral 'Rosa'	Carbonized rice hull	Pure	Yamakami et al. (2009)
Brassocattleya 'Pastoral' x *Laeliocattleya* 'Amber Glow'	Plantmax	Pure	Villa et al. (2007)
Brassavola tuberculate	Almond seed	Pure	Santos and Teixeira (2010)
Brassavola tuberculate	Sphagnum Charcoal Coconut fiber	Pure Pure Pure	Macedo et al. (2014)
Brassavola tuberculate	Sphagnum	Pure	Sousa et al. (2015)
BLC. Cattleya drumbeat triumph x *BLC. Cattleya pastoral*	Sugarcane bagasse + ceramic shards Sugarcane bagasse + charcoal Sugarcane bagasse + pine bark	(1:1) (1:1) (1:1)	Meurer et al. (2008)
BLC Nan Chang Silk 'Olimpic Torch'	Coconut fiber Composted pine bark Charcoal Composted pine bark + coconut fiber Coconut fiber + charcoal Charcoal + composted pine bark Charcoal + composted pine bark + coconut fiber	Pure Pure Pure (1:1) (1:1) (1:1) (1:1:1)	Dronk et al. (2012)
Cattleya chocolate drop x (*C. guttata x L. tenebrosa*)	Coconut powder	Pure	Colombo et al. (2005)
Cattleya forbesii	Peat + gravel No. 2	(1:1)	Seidel Júnior and Venturieri (2011)

continue

continuation

Cattleya intermedia	Coconut fiber Pine bark + coconut fiber	Pure (1:1)	Lone et al. (2008)
Cattleya intermedia	Pine bark + coconut fiber + carbonized rice husk + charcoal	(1:1:1:1)	Schinitzer et al. (2010)
Cattleya intermedia	Coconut fiber + pine bark + carbonized rice husk + gravel	(1:2:1:1)	Sasamori et al. (2014)
C.intermedia X *Hadrolaelia purpurata*	Rice husk + pine bark	(1:1)	Sorace et al. (2009)
C. labiata x (*C. forbesii* x *C. labiata*)	Coffee husk + coconut powder Coffee husk + carbonized rice husk	(1:1) (1:1)	Assis et al. (2011)
Cattleya labiata × *Cattleya forbesii*	Pine bark + carbonized rice husk Coconut fiber	(2:1) Pure	Yamakami et al. (2006)
Cattleya loddgesii 'Alba' x *Cattleya loddgesii* 'Atibaia'	Carbonized rice hull Piassava fiber	Pure Pure	Araujo et al. (2007)
Catasetum schmidtianum.	Chilean moss + vermiculite + carbonized rice straw + charcoal	(1:1:1:1)	Souza and Karsburg (2016)
Dendrobium nobile Lindl.	Coxim (diced coconut) Coxim + eucalyptus bark + charcoal	Pure (1:1:1)	Demattê and Graziano (2000)
Dendrobium nobile Lindl.	Vermiculite + rice husk Vermiculite + charcoal + milled styrofoam	(1:1) (1:1:1)	Corrêa et al. (2000)
Dendrobium nobile Lindl.	Plantmax + charcoal + milled styrofoam	(1:1:1)	Moraes et al. (2002)
Dendrobium nobile Lindl.	Defibered coconut Coconut powder + diced coconut	Pure (1:1)	Assis et al. (2005)
Dendrobium nobile Lindl.	Almond seed	Pure	Santos and Teixeira (2010)
Dendrobium nobile Lindl.	Fern fiber	Pure	Vichiato et al. (2014)
Dendrobium phalaenopsis var. *schroederianum* x *Dendrobium bigibbum* var. *compactum*	Charcoal	Pure	Macedo et al. (2011)
Doritaenopsis Queen Beer 'Mantefon	Peat moss	Pure	Kim et al. (2016)
Laeliocattleya gold digger	Carbonized rice husk Coconut fiber S-10 Beifort® Coconut fiber + carbonized rice husk S-10 Beifort® + coconut fiber S-10 Beifort® + carbonized rice husk	Pure Pure Pure (1:1:1) (1:1:1) (1:1:1)	Nadal et al. (2016)
Laelia pulcherrima	Corn cob	Pure	Figueiredo and Kolb (2013)
Laelia purpurata	peat + gravel No. 2	(1:1)	Seidel Júnior and Venturieri (2011)

continue

continuation

Laelia tenebrosa	Coconut powder + pine bark Coconut powder + pine bark + charcoal + walnut shells	(1:1) (1:1:1:1)	Antonietti et al. (2014)
Maxillaria picta	Vermiculite + charcoal Vermiculite + carbonized rice straw	(1:1) (1:1)	Faria et al. (2001)
Miltonia clowesii	Pine bark + coconut fiber + carbonized rice husk + charcoal	(1:1:1:1)	Schinitzer et al. (2010)
Miltonia flavescens	Coconut powder Pine bark	Pure Pure	Muller et al. (2007)
Miltonia regnellii x *Oncidium concolor*	Sugarcane bagasse powder + coconut powder	(1:1)	Stegani (2006)
Miltonia regnellii x *Oncidium concolor*	Sugar cane bagasse powder Coconut powder Sugarcane bagasse powder + styrofoam Sugarcane bagasse powder + pine bark Sugarcane bagasse powder + coconut powder	Pure Pure (1:1) (1:1) (1:1)	Yamamoto et al. (2009)
Miltonia regnelli x *Oncidium crispum*	Carbonized rice husk	Pure	Yamakami et al. (2009)
Oncidium baueri	Vermiculite	Pure	Faria et al. (2001)
Oncidium baueri	Coconut powder Defibered coconut + coconut powder	Pure (1:1)	Assis et al. (2008)
Oncidium baueri	Chilean moss + charcoal + styrofoam balls	(1:1:1)	Souza et al. (2014)
Oncidium baueri	Pine bark + coffee husk Pine bark + coconut fiber	(1:1) (1:1)	Mora et al. (2015)
Oncidium baueri	S-10Beifort® + carbonized rice husk S-10Beifort® + carbonized rice husk + coconut fiber	(1:1) (1:1:1)	Nadal et al. (2015)
Oncidium baueri	S-10Beifort®	Pure	Assis et al. (2015)
Oncidium baueri	Coconut fiber	Pure	Rodrigues et al. (2016)
Oncidium flexuosum Sims.	Almond seed	Pure	Santos and Teixeira (2010)
Oncidium sarcodes	Pine bark + styrofoam + charcoal Vermiculite + carbonized rice husk + charcoal + styrofoam Pine bark Pine bark + charcoal	(1:1:1) (1:1:1:1) Pure (1:1)	Rego et al. (2000)
Phalaenopsis	Sphagnum		Xun and Ichihashi (2001)

continue

continuation

Phalaenopsis amabilis L.	Organic compost Fertile peat FG2® Fibraflor®	Pure Pure Pure	Venturieri and Arbieto (2011)
Schomburgkia crispa,	Pine bark + styrofoam + charcoal Vermiculite + Carbonized rice husk + charcoal + styrofoam Pine bark	(1:1:1) (1:1:1:1) Pure	Rego et al. (2000)
Vanda tecelata x *Vanda gordon dillon*	Sugarcane bagasse + ceramic shards Sugarcane bagasse + charcoal Sugarcane bagasse + pine bark	(1:1) (1:1) (1:1)	Meurer et al. (2008)

In relation to the mixture of different sources for substrate composition, there is also no single ideal blend for all epiphytic orchids and that also meets all growing environments. For the same species, the substrate that presents the best result in one place may be inadequate in another region, where climatic conditions are distinct. In the same growing environment, the most appropriate substrates also vary according to the epiphytic orchid species (SHIRAKI; DIAS, 2012).

Demattê and Demattê (1996) described that many substrates can be used for cultivating epiphytic orchids. Among the substrates, there are those of plant origin (sphagnum, coconut fiber, pine bark, tree seeds, açaí seed, charcoal, carbonized rice husk, piassava, coffee husk, sugarcane bagasse powder, among others), mineral origin (vermiculite, expanded clay, and gravel), and synthetic materials (polystyrene and phenolic foam), with no material or mixture of materials considered universally valid as a substrate for all species (ABAD, 1991), leading to the need to test the best substrate or even the best one for each species and under different management.

Substrates derived from renewable sources

Xaxim is obtained by the defibration of the fern (*Dicksonia sellowiana* Hook) stem, which takes approximately 15 to 18 years to reach the ideal stage for extraction. However, this plant is at risk of extinction due to its indiscriminate extraction (SILVA, 1986; LORENZI; SOUZA, 2001; SOUZA, 2003). Thus, since 1992, the Law 9,519 has banned the extraction of fern in native forest (KÄMPF, 2000) and the Conama Resolution No. 278/2001 prohibits extraction in the Brazilian territory (SOUZA, 2003).

With the prohibition of xaxim commercialization and the growing concern with the environment, different types of agroindustrial residues have been studied and progressively applied as substrate in order to offer alternatives to seedling producers and minimize the environmental impact caused by the generated solid residues (PELIZER et al., 2007; ROSA et al., 2001).

Sugarcane bagasse and sugarcane bagasse powder

Sugarcane bagasse, a residue obtained after juice extraction, is among the agroindustrial residues with potential for use in seedling production, being widely available and presenting a high stability of physical characteristics (BARROS et al., 2010).

It presents a good particle stability, has a good total porosity and density, retains large amounts of water, and remains moist for a long time (MEURER et al., 2008). In the absence of rainfall or irrigation, it can transfer water to the velamen by contact or raise relative humidity in the environment near the pot, keeping the moisture content high (DEMATTÊ; DEMATTÊ, 1996).

Stegani (2006) evaluated the acclimatization of the orchid hybrid *Miltonia regnellii* x *Oncidium concolor* and found that the mixture of sugarcane bagasse powder and coconut powder in equal volumetric proportions can be used in the acclimatization phase. A similar result was observed by Meurer et al. (2008), who concluded that sugarcane bagasse mixed with ceramic shards, charcoal, or pine bark (1:1, v/v) can be used in the cultivation of orchids of the genera *Cattleya* and *Vanda*. Yamamoto et al. (2009) observed that sugarcane bagasse powder, sugarcane bagasse powder with chopped styrofoam (1:1, v/v), sugarcane bagasse powder with pine bark (1:1, v/v), and sugarcane bagasse powder with coconut powder (1:1, v/v) can be used in the cultivation of the hybrid *Miltonia regnellii* Rchb. f. x *Oncidium concolor* Hook.

Carbonized rice husk

Carbonized rice husk is a result of the incomplete combustion of rice husks at a high temperature and low oxygen conditions (WENDLING; GATTO, 2002). This material has the potential for use as a substrate due to its physical properties (MEDEIROS et al., 2008). Rice husk, when carbonized, presents a high drainage capacity, good aeration, easy handling, slightly alkaline pH, in addition to presenting in its composition potassium (K) and calcium (Ca), which are macronutrients essential for plant development (TABAJARA; COLÔNIA, 1986), Silicon (Si), among others. It also presents a physical and chemical stability of the structure, being resistant to decomposition (MEDEIROS et al., 2008).

This material is indicated for use in mixtures for orchid cultivation (YAMAKAMI et al., 2009; ARAUJO et al., 2007; SORACE et al., 2009). Due to its high macroporosity, it is necessary to combine it with elements of lower porosity, such as coconut fiber and vermiculite (KRATZ et al., 2013).

Yamakami et al. (2009) found that carbonized rice husks might be an alternative to xaxim fiber in the cultivation of the hybrid orchids *Brassocattleya pastoral* ‘Rosa’ and *Miltonia regnelli* x *Oncidium crispum*. Zandoná et al. (2014) observed that the mixture of carbonized rice husks with coconut fiber, combined in a ratio of 1:1 (v/v), was more efficient in the vegetative development of *Arundina graminifolia* during the acclimatization phase. On the other hand, the carbonized rice husk alone did not provide satisfactory results.

Coffee husk

Coffee husk is rich in organic compounds and other elements such as caffeine and tannins (PANDEY et al., 2000). It has the potential to be used as a substrate for orchid cultivation (ASSIS et al., 2011; MORA et al., 2015), providing benefits to nature, such as its use in production areas. Assis et al. (2011) observed that coffee husk mixed with coconut powder or carbonized rice husk can be used in the cultivation of the hybrid (*C. forbesii* x *C. labiata*) x *C. labiata*, not being indicated as a single substrate. On the other hand, for *Oncidium baueri*, Mora et al. (2015) described that mixtures of pine bark with coffee husk and coconut fiber provided favorable results in the cultivation.

Pine bark

The outer bark of the pine trunk is a residue of the paper and furniture industries. It has basically cellulose in its composition and its use occurs after the material is composted and ground, which allows a great particle size amplitude, from powder to several centimeters, an important characteristic for water retention. The pine bark is a material with a good drainage, pH between 3.5 and 5.9 (TAKANE et al., 2013), and can be used in orchid cultivation.

Muller et al. (2007) were successful with the use of coconut powder and pine bark during the acclimatization phase of *Miltonia flavescens*, while Dronk et al. (2012) observed that composted pine bark, coconut fiber, and charcoal can be used as alternative substrates to xaxim for BLC Nan Chang Silk 'Olimpic Torch'.

Charcoal

During charcoal production process, there is an excess of small pieces of this material, which has a porous structure and when mixed with other materials, such as coconut fiber, carbonized rice husk, and pine bark, increases porosity, water retention capacity, and assists in the proliferation of microorganisms beneficial to orchid development (ZANETTI et al., 2003).

Macedo et al. (2011) recommend the cultivation of *Dendrobium phalaenopsis* var. *Oncidium schroederianum* x *Dendrobium bigibbum* var. *compactum* in a substrate constituted by charcoal. Souza et al. (2014) concluded that the composite of Chilean moss, charcoal, and styrofoam under the same proportions is suitable for acclimatization of *Oncidium baueri* seedlings, while substrates with coconut fibers are less efficient. Santos and Smozinski (2015) recommend the use of charcoal and pine bark for the acclimatization of *Epidendrum ibaguense* seedlings.

Sphagnum

Sphagnum is a moss coming from plains and/or peat bogs, covering only 3% of the terrestrial surface (CHARMAN, 2002). These regions are considered a terrestrial carbon reservoir, with potential for global climate change, being vital to the preservation of these ecosystems (FROLKING et al., 2006). Studies have been dedicated to the preservation and management of these ecosystems (FUKUTA et al., 2012; BULLOCK et al., 2012). In Brazil, sphagnum collection is banned by Ibama due to the indiscriminate collection at the riverside (SOUZA, 2003), being the sphagnum used imported from Chilean peat.

The sphagnum presents a low density and high water retention capacity, being used in mixture with other materials aiming at improving the physical characteristics, being recommended for orchids such as *Sophronitis*, *Miltonia*, and *Paphiopedilum*, both for the acclimatization phase of seedlings and cultivation of adult plants (KÄMPF, 2000).

Xun and Ichihashi (2001) evaluated growth and nutrient absorption of *Phalaenopsis* and observed that plants cultivated in sphagnum showed a higher growth in relation to other substrates because they have physical characteristics that allow a fast fixation of plants.

Venturieri and Arbieto (2011), in studies with the substrates Fibraflor®, Fertile Peat FG2®, vermiculite, coconut shell, decomposed pine bark, organic compost, sphagnum, and defibrated xaxim in the acclimatization of *Phalaenopsis amabilis* L. concluded that substrates of higher performance were those with sphagnum and xaxim. However, in the impossibility of obtaining sphagnum, which is also a product of extractivism, the organic compound, Fertile Turf FG2® or Fibraflor® could be used.

Macedo et al. (2014) concluded that the substrates sphagnum, charcoal, and/or coconut fiber can be used in the acclimatization of plants of *Brassavola tuberculata*. Sousa et al. (2015) consider that sphagnum is the most suitable substrate for the survival and initial growth of *B. tuberculata* in the acclimatization phase. Souza and Karsburg (2016) found that the substrate composed of Chilean moss, vermiculite, carbonized rice husk, and charcoal, under the same proportions, promoted the most adequate conditions for the development of *C. schmidtianum*.

Fiber and powder of coconut

Fiber and powder of coconut are considered promising alternative substrates for the cultivation of epiphytic orchids (ASSIS et al., 2005, 2008; LONE et al., 2008; DRONK et al., 2012; ZANDONÁ et al., 2014; MORA et al., 2015).

Coconut fiber is a byproduct of coconut water industrialization and is a good quality material in the production of substrates because it is inert, has a high porosity, low cost, high availability, and a long life without altering its physical characteristics and possibility of sterilization, being adapted to the production of ornamental plants (CARRIJO et al., 2002; ROSA et al., 2001; JASMIM et al., 2006).

Coconut powder is a residue from the fibrous material processing and has a high percentage of lignin (35-45%) and cellulose (23-43%) and a low percentage of hemicellulose (3-12%), which is the fraction vulnerable to microorganism attack. These characteristics confer to the substrate of coconut fiber a high durability, being recommended for long-cycle crops such as ornamental plants (NOGUEIRA et al., 2000).

Teo and Tan (1993) consider coconut powder to be an excellent organic material for substrate formulations because of its high potential for moisture retention, high porosity, biodegradability, and rooting stimulator. It is a 100% natural culture medium indicated for seed germination, plant propagation in nurseries, and cultivation of flowers and vegetables (ROSA et al., 2001).

Demattê and Demattê (1996) recommended the substitution of xaxim by pure coxim® (coconut fiber) or in mixture with charcoal or *Eucalyptus grandis* bark in the cultivation of epiphytic orchids.

Demattê and Graziano (2000) evaluated the cultivation of *Dendrobium nobile* in xaxim, blocks of coconut fiber, eucalyptus bark, and coxim mixtures with eucalyptus bark and charcoal and observed that the coxim, as well as its mixture with eucalyptus bark and charcoal as plant substrates, can be used in the cultivation of *Dendrobium nobile* because they have adequate nutritional qualities. In another experiment, Assis et al. (2005) observed that the substrates defibered coconut and coconut powder in mixture with coconut in cubes could be used in the cultivation of the same species.

For the acclimatization phase of the orchid *Cattleya chocolate drop* x (*C. guttata* x *L. tenebrosa*), Colombo et al. (2005) observed that the substrate coconut powder is indicated for the cultivation of this species. However, Lone et al. (2008) observed that the substrate coconut fiber or the mixture of pine bark with coconut fiber (1:1, v/v) are the most suitable for acclimatization of *Cattleya intermedia*. Sasamori et al. (2014) evaluated the development of seedlings of the same species and obtained satisfactory results with the mixture of coconut fiber, pine bark, carbonized rice husk, and gravel, resulting in a higher shoot height.

In an experiment on the use of different concentrations of growth regulators and alternative substrates in substitution to agar in the culture medium for multiplication and in vitro rooting of *Oncidium baueri*, Rodrigues et al. (2016) found that coconut fiber could be used both in the multiplication phase and in the in vitro rooting. However, Assis et al. (2008) evaluated the same species and concluded that the substrates coconut powder and the mixture of defibered coconut with coconut powder provided adequate conditions for the species development. Antonietti et al. (2014) obtained the best results for *Laelia tenebrosa* growth with substrates of coconut powder with pine bark and coconut powder with pine bark, charcoal, and walnut shells.

Plantmax

Plantmax is a commercial substrate composed of processed bark, expanded vermiculite, processed peat, and granulated charcoal, being free of pests, diseases, and weeds and has been widely used in the acclimatization of micropropagated plants (MORAES et al., 2002; MENEGUCE et al., 2004;

VILLA et al., 2007).

According to Hoffmann (1999), Plantmax exhibits characteristics that favor seedling growth after emitting adventitious roots such as the physical (porosity, texture, drainage, and low compaction) and chemical properties (presence of nutrients and pH adequate for seedling growth and development).

When evaluating the acclimatization of *Dendrobium nobile* Lindl., Moraes et al. (2002) observed that the mixture of vermiculite with the commercial substrate Plantmax and the combination of Plantmax with charcoal and milled styrofoam could be used as alternative substrates to xaxim. Meneguce et al. (2004) concluded that the mixture of sand and Plantmax is an efficient substitute of xaxim for the commercial cultivation of *Epidendrum ibaguense*.

According to Villa et al. (2007), the substrate Plantmax is an efficient component in the formulation of substrates for the acclimatization of *Brassocattleya* 'Pastoral' x *Laeliocattleya* 'Amber Glow'. However, in general, plants cultivated with mixtures containing coffee husk took a longer time to reach the commercialization point.

Peat

Peat is formed by a fossil, organomineral substance originated from the decomposition of plant residues in the presence of a low oxygen content and found in floodplains such as those of river, coastal plains, and lacustrine regions (FRANCHI, 2000). This material has a high organic matter content, low pH value, low nutrient availability, high buffering power, high water retention capacity, and good aeration, being the main component for the production of substrates for seedlings (BURÉS, 1997). Peat is one of the main components of substrates in Europe, North America, and the United Kingdom (WEVER, 1991; MAHER et al., 2007).

The physical and chemical properties of the peat depend mainly on the origin of its plant residues, its degree of decomposition, and physical and biochemical alterations occurring in situ (PUUSTJARVI; ROBERTSON, 1975). The sphagnum peat (blonde peat) presents a good aeration, high water retention capacity, and low pH values. On the other hand, the black peat does not have chemical and physical properties very favorable to its use in the culture media because it becomes difficult to be moistened after drought and tends to compaction. These characteristics are related to its fine texture due to a high decomposition. For these reasons, it is mostly used as an organic soil improver, but can be used in substrate mixtures when improved with other materials (VERDURE, 1981; NORGAARD, 1991; KUEPPER, 2004).

Seidel Júnior and Venturieri (2011), when studying the ex vitro acclimatization of seedlings of *Cattleya forbesii* and *Laelia purpurata* in different substrates, concluded that xaxim was the best substrate for *C. forbesii*, with the possibility of being substituted by the mixture of peat and gravel No. 2 (1:1, v/v). For *L. purpurata*, the best substrate was the mixture of peat and gravel No. 2 (1:1, v/v).

Substrate S10-B

The substrate S-10 B (Beifort®) is a compound of organic residue from the agroindustry based on seed, bagasse, and stalk of grape, as well as ash, peat, and charcoal. The substrate has a high water retention capacity, excellent drainage capacity, and a pH around 5.5 ± 0.5.

In an experiment on the acclimatization of *Oncidium baueri*, Assis et al. (2015) tested the S-10 Beifort®, carbonized rice husk, coconut fiber, and the mixtures of S-10 Beifort® + carbonized rice husk, S-10 Beifort® + coconut fiber, and S-10 Beifort® + carbonized rice husk + coconut fiber. They reported no significant difference in relation to the analyzed variables, such as the percentage of survival, shoot length, and number of budding. However, they indicated the S-10 Beifort® due to its availability in the southern region of Brazil.

According to Nadal et al. (2015), mixtures of S-10Beifort® with carbonized rice husk or with carbonized rice husk and coconut fiber can be adopted in the acclimatization of *Oncidium baueri*. In addition, in the evaluation of substrates for the acclimatization of *Laeliocattleya gold digger*, Nadal et al. (2016) observed that S-10 Beifort®, carbonized rice husk, coconut fiber, as well as mixtures of coconut fiber with carbonized rice husk and S-10 Beifort® with coconut fiber or carbonized rice husk were the most indicated.

Vermiculite

Vermiculite is an expanded mica form obtained by heating it at temperatures above 1000 ℃. This material has a very light, soft, sterile structure with a good aeration, high cation exchange capacity, good water retention and good availability of Mg and K (GONÇALVES et al., 2000). In addition, the vermiculite can be used pure or in mixtures to promote a higher aeration and porosity to other less porous substrates (WENDLING; GATTO, 2002).

Corrêa et al. (2000) studied the development of keikis (budding of pseudobulbs) of *Dendrobium nobile* Lindl. and obtained good results for the number of buds by using mixtures of vermiculite with rice husk or vermiculite, charcoal, and milled styrofoam. Rego et al. (2000), in experiments with the native Brazilian orchid *Oncidium sarcodes* and *Schomburgkia crispa*, concluded that mixtures containing pine bark, styrofoam, and charcoal and a mixture of vermiculite, carbonized rice husk, charcoal, styrofoam, and pine bark may be a substitute for xaxim. Faria et al. (2001) evaluated the development of *Oncidium baueri* in different materials and observed that the best alternative substrate to xaxim was vermiculite. On the other hand, the best substrates to *Maxillaria picta* were the mixture of vermiculite with charcoal or vermiculite with carbonized rice husk.

Table 1 shows the results of studies carried out with the use of different substrates for orchid cultivation.

Conclusion

Different substrates can be used for seedling production and cultivation of epiphytic orchids. However, many studies are focused on the ecologically correct cultivation and rational use of agroindustrial residues available in each region. Thus, the main substrates that have been used alone or in a mixture for the cultivation of these plants are fiber and powder of coconut, carbonized rice husk, charcoal, and pine bark.

References

ABAD, M. Los sustratos hortícolas y técnicas de cultivo sin suelo. In: RALLO, L.; NUEZ, F. *La horticultura Española en la C. E.* Réus: Horticultura S.L., 1991. 280 p.

ANTONIETTI, D.; BUTTINI, S.; COSTA ZONETTI, P. da; GUIMARÃES, A. T. B.; STEFANELLO, S. Plant growth of *Laelia tenebrosa* Rolfe treated with gibberellic acid and grown on different substrates. *Idesia*, Arica, v. 32, n. 3, p. 7-11, 2014.

ARAUJO, A. G.; PASQUAL, M.; DUTRA, L. F. I.; CARVALHO, J. G.; SOARES, G. A. Substratos alternativos ao xaxim e adubação de plantas de orquídea na fase de aclimatização. *Ciência Rural*, Santa Maria, v. 37, n. 1, p. 569-571, 2007.

ASSIS, A. M.; FARIA, R. T.; COLOMBO, L. A.; CARVALHO, J. F. R. P. Utilização de substratos à base de coco no cultivo de *Dendrobium nobile* Lindl. (Orchidaceae). *Acta Scientiarum Agronomy*, Maringá, v. 27, n. 1, p. 255-260, 2005.

ASSIS, A. M.; FARIA, R. T.; UNEMOTO, L. K.; COLOMBO, L. A. Cultivo de *Oncidium baueri* Lindley (Orchidaceae) em substratos a base de coco. *Ciência e Agrotecnologia*, Lavras, v. 32, n. 1, p. 981-985, 2008.

ASSIS, A. M.; RODRIGUES, D. B.; NADAL, M. C.; SCHUCH, M. W.; FARIA, R. T.; PEIL, R. M. N. Aclimatização de *Oncidium baueri* em resíduos agrícolas. In: CONGRESSO BRASILEIRO DE FLORICULTURA E PLANTAS ORNAMENTAIS E CONGRESSO BRASILEIRO DE CULTURA DE

TECIDOS DE PLANTAS, 20., 7., 2015, Piracicaba. *Resumos*... Piracicaba: Editora, 2015. p. 105-115.

ASSIS, A. M.; UNEMOTO, L. K.; YAMAMOTO, L. Y.; LONE, A. B.; SOUZA, G. R. B.; FARIA, R. T.; ROBERTO, S. R.; TAKAHASHI, L. S. A. Cultivo de orquídea em substratos à base de casca de café. *Bragantia*, Campinas, v. 70, n. 1, p. 544-549, 2011.

BARROS, F.; VINHOS, F.; RODRIGUES, V. T.; BARBERENA, F. F. V. A.; FRAGA, C. N. Orchidaceae. In: FORZZA, R. C. (Org.). *Catálogo de plantas e fungos do Brasil*. Rio de Janeiro: Jardim Botânico do Rio de Janeiro, 2010. v. 2, p. 1344-1426.

BULLOCK, C. H.; COLLIER, M. J.; CONVERY, F. Peatlands, their economic value and priorities for their future management - Theex ample of Ireland. *Land Use Policy*, Londres, v. 29, n. 1, p. 921-928, 2012.

BURÉS, S. *Sustratos*. Madrid: Ediciones Agrotécnicas, 1997. 341 p.

CARRIJO, O. A.; LIZ, R. S.; MAKISHIMA, N. Fibra da casca do coco verde como substrato agrícola. *Horticultura Brasileira*, Brasília, v. 20, n. 1, p. 533-535, 2002.

CHARMAN, D. J. *Peatlands and environmental change*. Chichester: John Wiley & Sons, 2002. 301 p.

COLOMBO, L. A.; FARIA, R. T.; ASSIS, A. M.; FONSECA, I. C. B. Aclimatização de um híbrido de *Cattleya* em substratos de origem vegetal sob dois sistemas de irrigação. *Acta Scientiarum*, Maringá, v. 27, n. 1, p. 145-150, 2005.

CORRÊA, R. M.; QUEVEDO, P. P.; FARIA, R. T. Avaliação de diferentes substratos no desenvolvimento de Keiks de *Dendrobium nobile* (Orchidaceae) visando a preservação xaxim. In: V MOSTRA ACADÊMICA DE TRABALHOS DE AGRONOMIA - MATA, 5., 2000, Londrina. *Resumos*... Londrina, 2000. p. 87-87. v. 4.

DEMATTÊ, J. B. I.; DEMATTÊ, M. E. S. P. Estudos hídricos com substratos vegetais para cultivo de orquídeas epífitas. *Pesquisa Agropecuária Brasileira*, Brasília, v. 31, n. 1, p. 803-813, 1996.

DEMATTÊ, M. E. S. P.; GRAZIANO, T. T. Growth of *Dendrobium nobile* Lindl. as related with nutrient concentration in the growing media. *Acta Horticulturae*, Leuven, v. 511, n. 1, p. 265-270, 2000.

DRONK, A. G.; SILVA, A. P. V.; CUQUEL, F. L.; FARIA, R. T. Desenvolvimento vegetativo de híbrido de orquídea em diferentes substratos. *Semina: Ciências Agrárias*, Londrina, v. 33, n. 1, p. 2109-2114, 2012.

FARIA, R. T.; ASSIS, A. M.; CARVALHO, J. F. R. P. *Cultivo de orquídeas*. Londrina: Mecenas, 2010. 208 p.

FARIA, R. T.; REGO, L. V.; BERNARDI, A.; MOLINARI, H. Performance of diferents genotyps of brazilian orchid cultivation in alternatives substrates. *Brazilian Archives of Biology and Technology*, Curitiba, v. 44, n. 1, p. 337-342, 2001.

FERNANDES, C.; CORÁ, J. E.; BRAZ, L. T. Desempenho de substratos no cultivo do tomateiro do grupo cereja. *Horticultura Brasileira*, Brasília, v. 24, n. 1, p. 42-46, 2006.

FIGUEIREDO, L. D.; KOLB, R. M. Novo substrato para o cultivo de orquídeas: estudo do seu potencial de uso em plantas de *Laelia pulcherrima*. *Revista Brasileira de Biociências*. Porto Alegre, v. 11, n. 4, p. 405-413, 2013.

FONSECA, T. G. *Produção de mudas de hortaliças em substratos de diferentes composições com adição de* CO_2 *na* água *de irrigação*. 2001. Dissertação (Mestrado em Agronomia) - Escola Superior de Agricultura Luiz de Queiroz, Piracicaba.

FRANCHI, J. G. *Aplicação de turfa na recuperação de solos degradados pela mineração de areia*. 2000. Dissertação (Mestrado em Engenharia Mineral) - Escola Politécnica da Universidade de São Paulo, Butantã.

FROLKING, S.; ROULET, N. T.; FUGLESTVEDT, J. How northern peatlands influence the Earth's radiative budget: sustained methane emission versus sustained carbono sequestration. *Journal of Geophysical Research*, Anglia, v. 111, n. 1, p. 1-10, 2006.

FUKUTA, E.; SASAKI, A.; NAKATSUBO, T. Microclimate and production of peat moss Sphagnum palustre L. in the warm-temperate zone. *Plant Species Biology*, Flórida, v. 27, n. 1, p. 110-118, 2012.

GONÇALVES, J. L. M.; SANTARELLI, E. G.; MORAES NETO, S. P.; MANARA, M. P. Produção de mudas de espécies nativas: substrato, nutrição, sombreamento e fertilização. In: GONÇALVES, J. L. M.; BENEDETTI, V. (Ed.) *Nutrição e fertilização florestal*. Piracicaba: IPEF, 2000. p. 309-350.

HOFFMANN, A. *Enraizamento e aclimatização de mudas micropropagadas dos porta-enxertos de macieira Marubakaido e M-26*. 1999. Tese (Doutorado em Agronomia) - Universidade Federal de Lavras, Lavras.

JASMIM, J. M.; TOLEDO, R. R. V.; CARNEIRO, L. A.; MANSUR, E. Fibra de coco e adubação foliar no crescimento e na nutrição de *Cryptanthus sinuosus*. *Horticultura Brasileira*, Vitória da Conquista, v. 24, n. 1, p. 309-314, 2006.

KÄMPF, A. N. *Produção comercial de plantas ornamentais*. Guaíba: Agropecuária, 2000. 254 p.

KIM, H. J.; KIM, J.; DO, L. Y.; KIM, K. S.; KIM, Y. J. Growth and flowering of *Doritaenopsis Queen Beer* 'Mantefon'as affected by different potting substrates. *The Horticulture Journal*, Singapura, v. 85, n. 4, p. 360-365. 2016.

KRATZ, D.; WENDLING, I.; NOGUEIRA, A. C.; SOUZA, P. V. D. Utilização de resíduos urbanos e agroflorestais para produção de mudas de *Eucalyptus benthamii* e *Mimosa scabrella*. *Floresta e Ambiente*, Seropédica, v. 20, n. 1, p. 530-537, 2013.

KUEPPER, G. *Potting mixes for certified organic production.* National sustaintable agriculture information service, ATTRA. Arkansas: National Centre for Appropriate Technology, Fayetteville, 2004. 20 p.

LIMA, J. D.; MORAES, W. S.; MENDONÇA, J. C.; NOMURA, E. S. Resíduos da agroindústria de chá preto como substrato para produção de mudas de hortaliças. *Ciência Rural*, Santa Maria, v. 37, n. 1, p. 1609-1613, 2007.

LONE, A. B.; BARBOSA, C. M.; TAKAHASHI, L. S. A.; FARIA, R. T. Aclimatização de *Cattleya* (Orchidaceae), em substratos alternativos ao xaxim e ao esfagno. *Acta Scientiarum Agronomy*, Maringá, v. 30, n. 1, p. 465-469, 2008.

LORENZI, H.; SOUZA, H. M. *Plantas ornamentais do Brasil*. 3. ed. Nova Odessa: Plantarum, 2001. 1120 p.

MACEDO, M. C.; ROSA, D. B. C. J.; SOARES, J. S.; TATARA, M. B.; HOFMMANN, N. T. K.; ROSA, Y. B. C. J. Armazenamento de sementes e aclimatização de *Brassavola tuberculata* Hook. *Semina: Ciências Agrarias*, Londrina, v. 35, n. 1, p. 2883-2894, 2014.

MACEDO, M. C.; ROSA, Y. B. C. J.; SCALON, S. P. Q.; ROSA JÚNIOR, E. J.; VIEIRA, M. C.; TATARA, M. B. Substratos e intensidades de luz no cultivo de orquídea denfal. *Horticultura Brasileira*, Vitória da Conquista, v. 29, n. 1, p. 168-173, 2011.

MAHER, M.; PRASAD, M.; RAVIV, M. Organic soilless media component. In: RAVIV, M.; LIETH, J. H. (Ed.). *Soilless culture:* theory and practice. Paris: Elsevier, 2007. 459-504.

MEDEIROS, J. C.; MAFRA, A. L.; ALBUQUERQUE, J. A.; ROSA, J. D.; GATIBONI, L. C. Relação cálcio: magnésio do corretivo da acidez do solo na nutrição e no desenvolvimento inicial de plantas de milho em um Cambissolo Húmico álico. *Semina: Ciências Agrárias*, Londrina, v. 9, n. 3, p. 93-98, 2008.

MENEGUCE, B.; OLIVEIRA, R. B. D.; FARIA, R. T. Propagação vegetativa de *Epidendrum ibaguense* Lindl. (Orchidacea) em substratos alternativos ao xaxim. *Semina: Ciências Agrárias*, Londrina, v. 25, n. 12, p. 101-106, 2004.

MEURER, F. M.; BARBOSA, C.; ZONETTI, P. C.; MUNHOZ, R. E. F. Avaliação do uso de bagaço de cana-de-açúcar como substrato no cultivo de mudas de orquídeas. *Revista de Saúde e Biologia*, Campo Mourão, v. 3, n. 4, p. 45-50, 2008.

MORA, M. M.; ASSIS, A. M.; YAMAMOTO, L. Y.; PIVETTA, K. F. L.; FARIA, R. T. Resíduos agrícolas e argila expandida no cultivo de orquídea *Oncidium baueri* Lindl. *Semina: Ciências Agrárias*, Londrina, v. 36, n. 2, p. 39-46, 2015.

MORAES, L. M.; CAVALCANTE, L. C. D.; FARIA, R. T. Substratos para aclimatização de plântulas de *Dendrobium nobile* Lindl. (Orchidaceae) propagadas in vitro. *Acta Scientiarum*, Maringá, v. 24, n. 1, p. 1397-1400, 2002.

MULLER, T. S.; DEWES, D.; KARSTEN, J.; SCHUELTER, A. R.; STEFANELLO, S. Crescimento *in vitro* e aclimatação de plântulas de *Miltonia flavescens*. *Revista Brasileira de Biociências*, Porto Alegre, v. 5, n. 11, p. 252-254, 2007.

MYERS, N.; MITTLERMEIER, R. A.; MITTLERMEIER, C. G.; FONSECA, G. A. B.; KENT, J. Biodiversity hotspots for conservation priorities. *Nature,* Campinas, v. 403, n. 3, p. 853-858, 2000.

NADAL, M. C.; AMARAL, G. G.; OLIVEIRA, B. A. S.; SCHUCH, M. W.; FARIA, R. T.; ASSIS, A. M. Resíduo a base de uva: uma nova alternativa para a aclimatização de *Oncidium baueri*. In: CONGRESSO DE INICIAÇÃO CIENTÍFICA, 25., 2015, Pelotas. *Resumos...* Pelotas, 2015. p. 95-97.

NADAL, M. C.; SANTOS, B. A.; OXLEY, H. N.; SCHUCH, M. W.; FARIA, R. T.; ASSIS, A. M. Substratos para a aclimatização de *Laeliocattleia gold digger*. In: CONGRESSO DE INICIAÇÃO CIENTÍFICA, 25., 2016, Pelotas. *Resumos*... Pelotas, 2016. p. 21-24.

NOGUEIRA, P. A.; ABAD, M.; NOGUERA, V.; PUCHADES, R.; MAQUIEIRA, A. Coconut coir waste, a new viable ecologilly - Friendly peat substitute. *Acta Horticulturae*, Leuven, v. 517, n. 7, p. 279-286, 2000.

NORGAARD, J. B. Sedge peat mixed with rockwool and sphagnum peat as growth medium for pot plants. *Acta Horticulturae*, Leuven, v. 294, n. 32, p. 109-113, 1991.

PANDEY, A.; SOCCOL, C. R.; NIGAM, O.; BRAND, D.; MOHAN, R.; ROUSSOS, S. Biotechnological potential of coffee pulp and coffee husk for bioprecesses. *Biochemical Engineering Journal*, Toronto, v. 6, n. 2, p. 153-162, 2000.

PELIZER, L. H.; PONTIERI, M. H.; MORAES, I. O. Utilização de resíduos agro-industriais em processos biotecnológicos como perspectiva de redução do impacto ambiental. *Journal of Technology Management and Innovation*, Santiago, v. 2, n. 1, p. 118-127, 2007.

PUUSTJARVI, V.; ROBERTSON, R. A Physical and chemical properties. In: ROBINSON, D. W.; LAMB, J. G. D. (Ed.). *Peat in horticulture*. London: Academic Press, 1975. p. 25-38.

REGO, L. V.; BERNARDI, A.; TAKAHASHI, L. S. A.; FARIA, R. T. Desenvolvimento vegetativo de genótipos de orquídeas brasileiras em substratos alternativos ao xaxim. *Revista Brasileira de Horticultura Ornamental*, Campinas, v. 6, n. 4, p. 75-79, 2000.

RODRIGUES, D. B.; NADAL, M. C.; CAMARGO, S. S.; ASSIS, A. M.; SCHUCH, M. W.; PEIL, R. N. M.; FARIA, R. T. Reguladores de crescimento e substratos para a micropropagação de *Oncidium baueri* Lindl. *Semina: Ciências Agrárias*, Londrina, v. 37, n. 1, p. 2901-2910, 2016.

ROSA, M. F.; BEZERRA, F. C.; CORREIA, D.; SANTOS, F. J. S.; ABREU, F. A. P.; FURTADO, A. A. L.; BRÍGIDO, A. K. L.; NORÕES, E. R. V. *Utilização de coco como substrato agrícola*. Fortaleza: EMBRAPA Agroindústria Tropical, 2001. 24 p.

RUSCHI, A. *Orquídeas do estado do Espírito Santo*. 2. ed. Rio de Janeiro: Expressão e Cultura, 1997. 278 p.

SANTOS, C. B.; LONGHI, S. J.; HOPPE, J. M.; MOSCOVICH, F. A. Efeito do volume de tubetes e tipos de substratos na qualidade de mudas de *Cryptomeria japonica* (L. F.) D. Don. *Ciência Florestal*, Santa Maria, v. 10, n. 8, p. 1-15, 2000.

SANTOS, M. N.; TEIXEIRA, M. L. F. Semente de amendoeira (*Terminalia catappa* L.) (Combretaceae) como substrato para o cultivo de orquídeas epífitas. *Acta Scientiarum*, Maringá, v. 32, n. 12, p. 339-343, 2010.

SANTOS, M. R. A.; SMOZINSKI, C. V. Evaluation of different substrates on the acclimatization of *Epidendrum ibaguense* kunth plantlets. *Saber Científico*, Porto Velho, v. 4, n. 2, p. 57-66, 2015.

SASAMORI, M. H.; ENDRES-JÚNIOR, D.; DROSTE, A. Sobrevivência e desenvolvimento de plântulas de *Cattleya intermedia* Graham (Orchidaceae) micropropagadas e aclimatadas em substratos com fibra de coco. *Revista Pesquisas, Botânica*, Porto Alegre, v. 65, n. 11, p. 293-303, 2014.

SCHINITZER, J. A.; FARIA, R. T.; VENTURA, M. U.; SORACE, M. Substratos e extrato pirolenhoso no cultivo de orquídeas brasileiras *Cattleya intermédia* (John Lindley) e *Miltonia clowesii* (John Lindley) (Orchidaceae. *Acta Scientiarum. Agronomy*, Maringá, v.32, n.1, p.139-143, 2010.

SEIDEL JÚNIOR, D.; VENTURIERI, G. A. *Ex vitro* acclimatization of *Cattleya forbesii* and *Laelia purpurata* seedlings in a selection of substrates. *Acta Scientiarum. Agronomy*, Maringá, v. 33, n. 7, p. 97-103, 2011.

SEQUEIRA, L. G. C. C. *Avaliação de diferentes substratos e da inoculação de fungos rizoctonióides no crescimento inicial de Hadrolaelia perrinnii*. 2007. Dissertação (Mestrado em Gestão de Recursos Agroambientais) - Pós-Graduação – Instituto Ambiental de Campinas - IAC, Campinas.

SHIRAKI, J. N.; DIAS, E. M. *Apostila do curso de orquídeas*. São Paulo: Prefeitura de São Paulo, Secretaria do Verde e do Meio Ambiente, 2012. 110 p.

SILVA, F. S. C.; SILVA, S. P. C. O substrato na cultura das orquídeas, sua importância, seu envelhecimento. *Revista Oficial do Orquidário*, Rio de Janeiro, v. 11, n. 1, p. 3-10, 1997.

SILVA, W. *Cultivo de orquídeas no Brasil*. São Paulo: Nobel, 1986. 97 p.

SORACE, M.; FARIA, R. T.; FONSECA, I. C.; YAMAMOTO, L. Y.; SORACE, M. A. F. Substratos alternativos ao xaxim no cultivo do híbrido C*attleya intermedia* X *Hadrolaelia purpurata* (Orchidaceae), *Semina: Ciências Agrárias*, Londrina, v. 30, n. 6, p. 771-778, 2009.

SOUSA, G. G.; ROSA, Y. B. C. J.; MACEDO, M. C.; SOARES, J. S. Aclimatização de *Brassavola tuberculata* com a utilização de ANA em diferentes substratos. *Horticultura Brasileira*, Vitória da Conquista, v. 33, n. 1, p. 208-215, 2015.

SOUZA, M. Muito além do xaxim. *Natureza*, São Paulo, v. 182, n. 2, p. 32-37, 2003.

SOUZA, M. D. A.; KARSBURG, I. V. Substratos alternativos na aclimatação de *Catasetum schmidtianum* Miranda e Lacerda (Orchidaceae) micropropagadas. *Revista Biociências*, Taubaté, v. 22, n. 2, p. 36-41, 2016.

SOUZA, M. D. A.; SILVA, M. S. A.; KARSBURG, I. V. Aclimatação *ex vitro* de plântulas de *Oncidium baueri* Lindl. em diferentes substratos. *Enciclopédia Biosfera, Centro Científico Conhecer,* Goiânia, v. 10, n. 1, p. 102-121, 2014.

STEGANI, V. *Aclimatização de orquídea utilizando como substrato pó de bagaço de cana-de-açúcar*. 2006. Dissertação (Mestrado em Agronomia) - Universidade Estadual de Maringá, Maringá.

TABAJARA, S. M.; COLÔNIA, E. J. Casca de arroz e meio ambiente. *Revista Lavoura Arrozeira*, Porto Alegre, v. 21, n. 36, p. 10-12, 1986.

TAKANE, R. J.; YANAGISAWA, S. S.; GÓIS, E. A. *Técnicas em substratos para floricultura*. Fortaleza: Expressão: Gráfica e Editora, 2013. 148 p.

TEO, C. K. H.; TAN, E. H. Tomato production in cocopeat. *Planter*, Pensilvânia, v. 69, n. 15, p. 239-242, 1993.

VENDRAME, W.; FARIA, R. T.; SORACE, M.; SAHYUN, S. A. Orchid cryopreservation. *Ciência e Agrotecnologia*, Lavras, v. 38, n. 20, p. 213-229, 2014.

VENTURIERI, G. A.; ARBIETO, E. A. M. *Ex-vitro* establishment of *Phalaenopsis amabilis* seedlings in diferent substrates. *Acta Scientiarum,* Maringá, v. 33, n. 7, p. 495-501, 2011.

VERDURE, M. Improvment of physical properties of black peat. *Acta Horticulturae,* Leuven, v. 126, n. 1, p. 131-142, 1981.

VILLA, F.; PEREIRA, A. R.; PASQUAL, M.; ARAUJO, A. G. Influência de substratos alternativos na aclimatização de orquídea. *Revista Ceres*, Viçosa, MG, v. 54, n. 23, p. 501-505, 2007.

VICHIATO, M. R. D. M.; VICHIATO, M.; PASQUAL, M.; RODRIGUES, F. A.; CASTRO, D. M. D. Morphological effects of induced polyploidy in *Dendrobium nobile* Lindl.(Orchidaceae). *Crop Breeding and Applied Biotechnology*, Viçosa, v.1 4, n. 3, p. 154-159, 2014

WATANABE, D.; MORIMOTO, L. M.; MORIMOTO, M. S.; KIHARA, G. T. E. *Orquídeas - manual de cultivo (AOSP).* São Paulo: Editora Raízes Artes Gráficas, 2002. 300 p.

WENDLING, I.; GATTO, A. *Substratos, adubação e irrigação na produção de mudas*. Viçosa, MG: Aprenda Fácil, 2002. 146 p.

WEVER, G. Guide values for physical properties of peat substrates. *Acta Horticulturae*, Leuven, v. 294, n. 51, p. 41-47, 1991.

XUN, J.; ICHIHASHI, S. Studies on *Phalaenopsis* growth and the nutriente absorption in different potting materials. *Proceedings of APOC7*, Tokyo, v. 1, n. 1, p. 2-12, 2001.

YAMAKAMI, J. K.; FARIA, R. T.; STENZEL, N. M. C. Desenvolvimento vegetativo de *Brassocattleya* pastoral Rosa e *Miltonia regnelli* Rchb. f. x *Oncidium crispum* L. (Orchidaceae) em substratos alternativos à fibra de xaxim. *Científica*, Jaboticabal, v. 37, n. 1, p. 32-38, 2009.

YAMAKAMI, K. J.; FARIA, R. T.; MARINHO DE ASSIS, A.; VALLE REGO-OLIVEIRA, L. Cultivo de Cattleya Lindley (Orchidaceae) em substratos alternativos ao xaxim. *Acta Scientiarum. Agronomy*, Maringá, v. 28, n. 2, p. 523-526, 2006.

YAMAMOTO, L. Y.; SORACE, M.; FARIA, R. T.; TAKAHASHI, L. S.; SCHNITZER, J. A. Substratos alternativos ao xaxim no cultivo do híbrido primário *Miltonia regnellii* Rchb. f. x *Oncidium concolor* Hook. (Orchidaceae). *Semina: Ciências Agrárias*, Londrina, v. 30, n. 1, p. 1035-1042, 2009.

ZANDONÁ, A. P.; FARIA, R. T.; LONE, A. B.; HOSHINO, R. T. Alternative substrates to the sphagnum moss in the acclimatization of arundina graminifolia alba (Orchidaceae). *Ornamental Horticulture*, Campinas, v. 20, n. 1, p. 7-12, 2014.

ZANETTI, M.; CAZETTA, J. O.; MATTOS JÚNIOR, D.; CARVALHO, S. A. Uso de subprodutos de carvão vegetal na formação do porta-enxerto Limoeiro Cravo em ambiente protegido. *Revista Brasileira de Fruticultura*, Jaboticabal, v. 25, n. 1, p. 508-512, 2003.