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Seedling production *Cattleya eldorado* in substrates with nutritive solution under shading screens

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Abstract: In the production of seedlings, the choice and/or preparation of the substrate is of fundamental importance for the rapid establishment and growth of the plant. Given the increasing need for sustainable use of natural resources, the use of substrates, shading and mineral fertilization can be a differential factor in the production of seedlings of the most different plant species. The study was conducted with the aim of verify the effect of shading screens in the initial growth of *Cattleya eldorado* seedlings in substrates fertilized with nutritive solution. The experimental design was completely randomized 2x3x2 factorial with four replications. The studied factors: (T1)= crushed cupuaçupeel (sub1); (T2)= industrialized coconut fiber (sub2); (T3)= blend 50% sub1 + 50% sub2 with and without nutritive solution under red or black cromatinet. The analyzed variables were: aerial part height, number of leaves and chlorophyll a and b throught 300 days. Fertilization with nutritive solution promotes height growth and number of leaves results in higher levels of chlorophyll a and b, under red as black cromatinet, indicated for seedlings growth.
Key words: Mineral nutrition, Orchidaceae, chlorophyll.

Produção de mudas de *Cattleya eldorado* cultivadas sob telas coloridas em substratos com adição de solução nutritiva

Resumo: Na produção de mudas, a escolha e/ou preparo do substrato é de fundamental importância para o rápido estabelecimento e crescimento da planta. Frente à necessidade crescente de aproveitamento sustentável dos recursos naturais, o uso de substratos, sombreamento e fertilização mineral, pode ser um fator diferencial na produção de mudas das mais diferentes espécies vegetais. Diante do exposto, o trabalho foi realizado com objetivo de verificar o efeito de telas de sombreamento no crescimento inicial de mudas de *C. eldorado* em substratos fertilizados com adição de solução nutritiva. O delineamento experimental utilizado foi o inteiramente casualizado em esquema fatorial 2x3x2 com quatro repetições. Os fatores em estudo foram: (T1)= casca de frutos de cupuaçu triturada (sub1); (T2)= fibra de coco industrializada (sub 2); (T3)= 50% mistura de sub1 + 50% mistura de sub2 com e sem adição de solução nutritiva sob cromatinet vermelha e cromatinet preta. As variáveis avaliadas foram: a altura da parte aérea, número de folhas e clorofila a e b, ao longo de 300 dias após o transplantio. A fertilização com adição de solução nutritiva favorece o crescimento em altura e o número de folhas e resulta em maiores índices de clorofila a e b tanto em cromatinet vermelha quanto preta, sendo indicada para crescimento de mudas de *C. eldorado.*

Palavras-chave: Nutrição mineral, Orchidaceae, clorofilas.

Introduction

Orchidaceaeis considered the biggest and most specialized family among the angiosperms existing, with 800 genres and 24,000 species (DRESSLER, 2005; FAY and CHASE, 2009). Therefore, it represents about 7% to 8% of vascular plants and 40% of monocots (DALHLGREN et al., 1985; DRESSLER, 1993). It is spread over, almost, all regions of the world, especially in the tropical regions, which have the greatest wealth (Atwood, 1986), whereas the Neotropical region, in turn, host around 300 genera and 8.000 species (KRAHL et al., 2015; DRESSLER, 1981).

Studies of Orchidaceae's species have grown and their commercial production is becoming an important business around the globe, due to their large ornamental value as potted flower, cut flower or landscaping crop, because the plants are attractive and delight by their beauty. The family can be considered the most commercially valued (DEB and PONGENER, 2011; STORTI et al., 2011; GRIESBACH, 2002).

Through the last years, the Brazilian floriculture has been a very important economic activity for agribusiness. Today, the per capita flowers consumption, in Brazil, amounts to R$ 24.00. In 2012, the sector had revenues of R$ 4.8 billion, in 2013, R$ 5.2 billion and, in 2014, R$ 5.8 billion. These revenues demonstrate the growth of the sector, that was estimated, in 2014, on the order f 12%. Since 2006, the floriculture segment has recorded increases of 8% to 12% in volume and 15% to 17% in value (IBRAFLOR, 2017).

The Atlantic Forest and the Amazon region are considered the main Brazilian habitats of orchids, where there are endemic species with relevant ornamental and commercial potential, as *Cattleya warneri, Cattleya labiatae, Laelia purpurata* (Farias and Ribeiro, 2000), *C. araguaiensis, Cattleya eldorado, C. luteolae* and *C. violacea* (LACERDA, 1995).

C. eldorado is under risk of disappearance in nature, being respectively recognized as endangered species and species vulnerable to extinction (Storti et al., 2011; Barros et al., 2010) and occurs in a relatively small area of the Brazilian Amazon, restricted to the states of Amazonas and Pará (STORTI et al., 2011).

In this context, the creation of new technologies for the production of orchid seedlings have acknowledged importance, since the knowlegde concerning their nutritional requirements, substrates and luminosity during the early growth is still incipient.Orchids are epiphyte plants, they live on the trees of forests and need humidity to survive, absorbing their nutrients from the organic materials deposited on the trunk (FAJARDO et al., 2015; ASSIS, et al., 2011; DEMATTÊ and DEMATTÊ, 1996).

The selection of fertilized substrates is of paramount importance and, as well as the luminosity, is a basic factor in the growth of seedlings. Depending on the physical, chemical and biological properties of the substrate and the ability of capturing and using the light, plants can display different and decisive responses to survive and adapt to different environments.

The use of colored screens or fabrics, as coverage of greenhouses structures, aims to attenuate solar radiation and direct luminosity, providing conditions that promote photosynthesis and productivity of the plants (Saraiva et al., 2014). In the case of orchids, that have recognized slow growth, it is expected that providing ideal conditions of mineral nutricion and luminosity, among other factors, promote, especially, productivity and earliness of orchids flowering.

Because of the great genetic diversity and different nutritional needs (Smiderle et al., 2017a), there is no way to define only one standard of mineral fertilization which meets the requirements of all species, highlighting the need for specific programs for this purpose (SMIDERLE and SOUZA, 2016). Therefore, additional research is needed for a better understanding of the various technical and physiological aspects entailed by the use of substrates, shading and mineral fertilization aiming their implementation for the production of *C. eldorado* seedlings.

Given the above, the study was conducted in order to verify the effect of esubstratos fertilized shading screens with addition of nutrient solution in the initial growth of *C. eldorado* seedlings. The study was conducted in order of verify the effect of shading screens and substrates fertilized with addition of nutritive solution in the initial growth of *Cattleya eldorado* seedlings.

Material and Methods

The research was conducted in the seedling greenhouse of Embrapa Roraima, located at BR 174, Km 8, Distrito Industrial (Industrial District), at Boa Vista municipality (02º45'28"N, 60º43'54"W, 90 m above sea level). Boa Vista (RR) is located at the Tropical climatic zone (Smiderle et al., 2015). The climate in the region is, according to Köppen, Aw (rainy tropical with a short dry period) with average annual rainfall between 1700-2000 mm (Alves et al., 2016). The average annual temperature is 25.5 °C (SMIDERLE et al., 2017b).

The *C. eldorado* seedlings were obtained by in vitro germination and, at the time of transplantation, had a mean height of 3.5 cm. After chemical characterization, the substrates were placed in plastic pots of dark coloration, each with 10 cm of height, diameter of 12 cm and four holes in the base. To facilitate drainage and aeration of the root system was placed a 2 cm layer of crushed stone number two at the bottom of the containers.

The shading structure over the seedlings was made up of shading nets Cromatinet®, of Polysack, with 35% shading for red coloration and 50% for black coloration, the nets were stuck in the wooden structure with 3x3x1,5 meters of wide, length and height, respectively, with sprinkler irrigation scheduled every six hours througth the day, each with five minutes of duration. The pots with seedlings were placed on metal countertops, receiving two weekly watering of 30 mL of the solution proposed by Souza et al. (2015), applied to the end of the last daily irrigation to prevent lixiviation.

The substrate 1 (sub1) consisted of crushed cupuaçu peel, obtained of plants cultivated at the Experimental Station Confiança, from Embrapa Roraima, located at Cantá municipality (RR). The drying, in the air-circulation oven for 48 hours and the crushing of the peels, in mills, until obtain a granulated product, was performed at the Soils and Plants Laboratory of Embrapa Roraima. The industrialized substrate of coconut fiber (sub2) was purchased in the local market of Boa Vista (RR). Samples for determination of the substrates chemical composition were sent for the Soil Laboratory at Federal Universtity of Lavras, MG (UFLA) and the results atre presented in Table 1.

Table 1. Avarage chemical composition of crushed cupuaçu peel and industrialized coconut fiber substrates

Substrates	N	P	K	Ca	Mg	S
	%					
Crushed cupuaçu peel	1.05	0.03	0.26	0.21	0.18	0.01
Industrialized coconut fiber	0.32	0.01	0.45	0.00	0.05	0.01

The experimental design was completely randomized in a 2x3x2 factorial with four replications. Each plot with 4 seedlings (one seedling per container). The studied factors were: (T1)= crushed cupuaçu peel (sub1); (T2)= industrialized coconut fiber (sub2); (T3)= blend of 50% sub1 and 50% of sub2 with and without addiction of nutritive solution. Using a digital luximeter, the incident luminous flux was measured in the area of establishment of the seedlings (close to the apical meristem), to determine the illuminance provided by the different coverings.

This has been carried in the way of sampling by illuminance measure, each month, during the first seven days. The measures were performed in six times during the day (8h00min; 10h00min; 12h00min; 14h00min; 16h00min; 18h00min). For characterizing the transparency provided by the different coverings, it was used the average of the appraisals at the end of the 300 days after transplantation (DAT). The average temperature in the trial period was 25 ± 5 °C and the relative humidity of 50% to 60%.

The analysis related to the height (cm) and number of leaves of the *Cattleya eldorado* seedlings were conducted every 30 days. The seedling height values were obtained by measuring, with a millimeter rule, from soil level to apical meristem. The results were analyzed by regression considering the three substrates and the ten measurement periods (30, 60, 90, 120, 150, 180, 210, 240, 270, 300 DAT) for the seedlings without and with addition of nutritive solution.

Chlorophyll a and b contents were quantified between 9h00min and 10h00min at the 300DAT, which is sufficient time to obtain the plants of the *C. eldorado*. The analyzis were conducted by chlorophilometer on three points on each side of the leaf midrib, at the adaxial leaf surface, obtaining the general content per plot.

The results were analyzed by Analysis of Variance and the means were compared by Tukey's test with a P-value of 5% through SISVAR software (FERREIRA, 2011).

Results and Discussion

The plants and sessile autotrophic organisms, radiant energy are dependent on for their survival and competition in plant communities, and to do so, adapt the growth and development of to the available radiation in the environment (Frankline and Whitelam, 2005). In Figure 1, it is verified that, throughout ten hours monitoring the light incidence, there is a quadratic trend in three environments, following the polynomial equations generated by the collected data.

In the environment built without protection screen (outdoor - full sunlight - 110.0 klxm^{-2}) and the environment consisting of black Cromatinet with 50% shading (42.0 klxm^{-2}), where the *C. eldorado* seedlings were cultivated, there was reduction of 68.0 klx m^{-2} (53.7%) between 11h00min and 13h00min. Whilst, in the environment constituted by red

Cromatinet (35% of shading), the checked variation was 62.0 klxm^{-2} between 12h00min and 13h00min. However, comparing the black Cromatinet 50% with the red cromatinet 35%, there was decrease of 24.0 klx m^{-2} during the times of highest incidence of luminous flux (Figure 1).

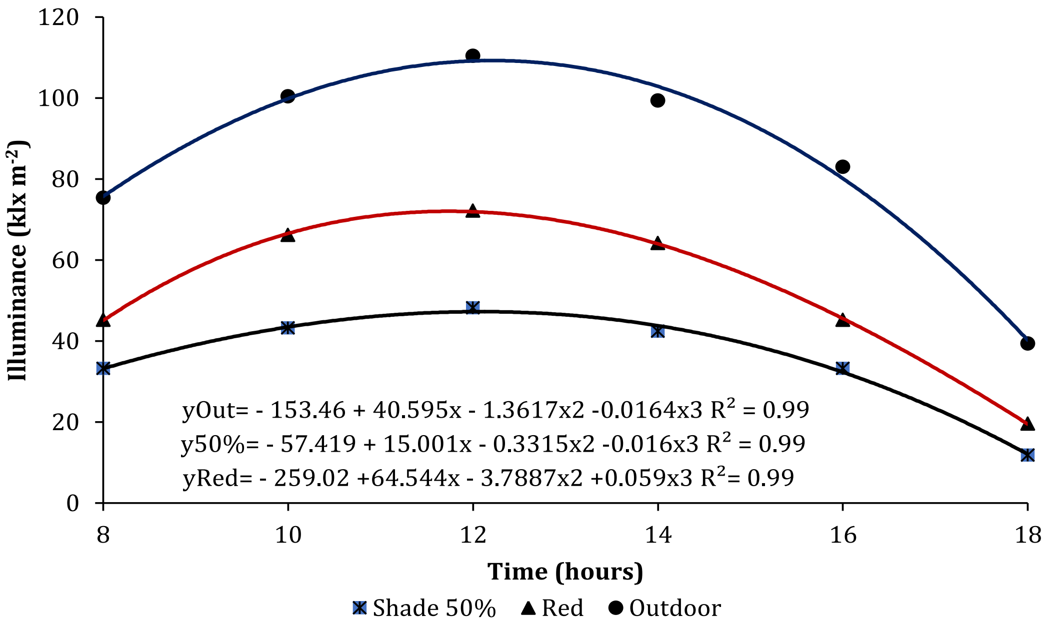

Figure 1. Illuminance rates obtained from 8h00min to 18:00 hours under different shade enviroments. Red = Red Cromatinet with 35% of shading. Black = Black Cromatinet with 50% of shading. Outdoor = natural environment without shading screens.

According to Farias et al. (2010), orchids depend on fertilization throughout their development. It is necessary to to know the requirements of the different phases during their annual cycle to determine the correct fertilization (Souza et al., 2013; Smiderle et al., 2016; Souza et al., 2017a), which becomes essential for good growth and development of orchids. Thus, in the Table 2, the significant effect of interaction, between the fertilization by addition of nutritive solution and substrate factors, is verified at the variables number of leaves and plant heigh.

The greatest plant growth was obtained from the sub1, presenting an average height of 8.6 cm (146%) with fertilization by addition of nutritive solution. So there was, for this substrate, an average increase of 5.1 cm in the period of 300 DAT. Amaral et al. (2010), evaluating the efficiency of substrates and fertilizer rates with the addition of nutrient solution on the growth of orchids of the genus Phalanopsis, noted that the dose of 1.5 g L^{-1} of mineral fertilizer of mineral fertilizer promoted linear increase of plant height and leaf number.

Table 2. Number of leaves and plant height (cm) of *Cattleya eldorado* seedlings grown on different substrates: crushed cupuaçu peel (sub1); industrialized coconut fiber (sub2); blend of 50% sub1 and 50% of sub2 (sub3), obtained with addition of nutritive solution (CF) and without addition of nutrient solution (SF) under red Cromatinet screen

Substrates	Number of leaves		Plant height (cm)	
	With or without addition of nutritive solution			
	CF	SF	CF	SF
sub 1	4.0 aA	2.9 bB	8.6 aA	7.2 aB
sub 2	3.9 aA	2.6 bB	7.0 bA	7.4 aA
sub 3	3.0 bA	3.4 aA	8.1 aA	7.1 aB
Mean	3.6	3.0	7.9	7.2

* Means followed by the same lowercase letters in the column and uppercase letters in the line do not differ by Tukey's test with a P-value of 5%.

The variable number of leaves presented a linear and positive effect (Figure 2A) on the unfolding of the interaction between substrates and fertilization with addition of nutritive solution for sub1 (crushed cupuaçu peel) and sub3 (blend of sub1 and sub2). While for industrialized coconut fiber (sub2), it was found a positive quadratic effect.

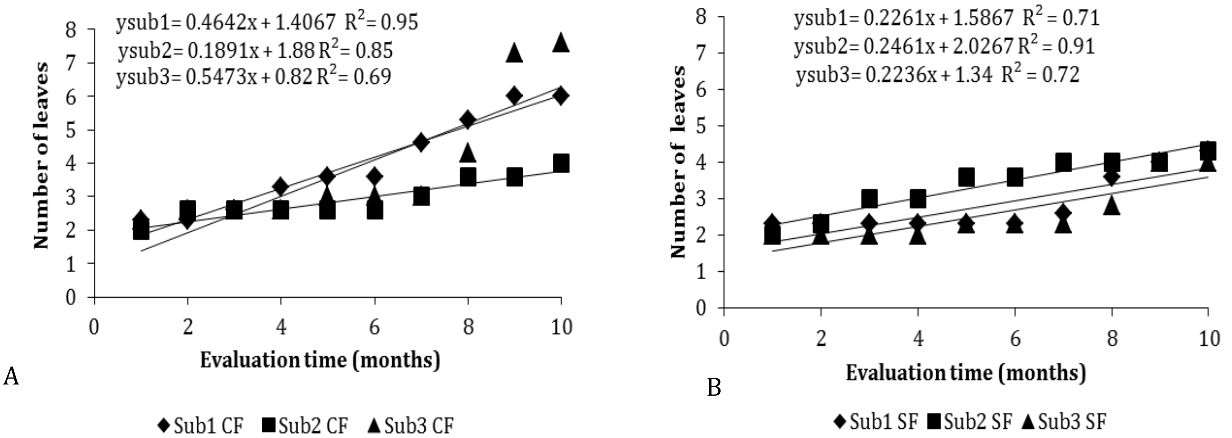

Figure 2. Number of leaves of *Cattleya eldorado* plants grown on substrates of crushed cupuaçu peel (sub1), industrialized coconut fiber (sub2), blend of 50% sub1 and 50% of sub2 (sub3) obtained (A) with the addition of nutritive solution (CF), and (B) without addition of nutritive solution (SF) along 300 DAT under red Cromatinet screen.

As well as observed in number of leaves variable, the interaction between the substrate and addition of nutritive solution factors affected the plants growth (Table 2 and Figure 3A). For all variables studied of treatments without addition of nutritive solution, the average growth was low. The maximum height of *C. eldorado* seedlings (16.5 cm) was obtained on the substrate 1 with addition of nutritive solution (Figure 3A). Therefore the nutrient solution used in this study can be considered an effective strategy to promote the seedling production of *C. eldorado* species in outstanding quality.

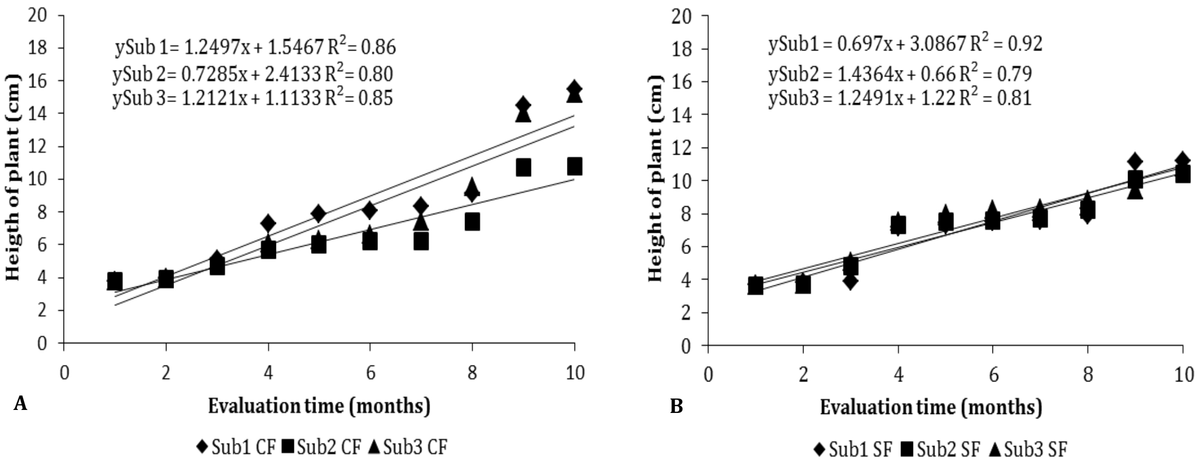

Figure 3. Plant height of *Cattleya eldorado* plants grown on substrates of crushed cupuaçu peel (sub1), industrialized coconut fiber (sub2), blend of 50% sub1 and 50% of sub2 (sub3) obtained (A) with the addition of nutritive solution (CF), and (B) without addition of nutritive solution (SF) along 300 DAT under red Cromatinet screen.

Gregg and Wang (1994) studied the application of mineral fertilizers orchids and found an increase in the total number of leaves and length of the plant. Similarly, Amberger-Ochserbauer (1997), got greater vegetative growth on *Phalaenopsis* orchids in experiments testing mineral fertilization. The positive responses on the application of mineral fertilizers are associated with the orchids needs for supply of nutrients along the entire development (FARIA et al., 2010; SOUZA et al., 2011a; SOUZA et al., 2011 b; SCHNITZER et al., 2015; SOUZA et al., 2017 b).

Researches by Pasqual et al. (2011), checking the influence of cultivation environment and calcium silicate concentrations at in vitro growth of a native orchid species (*Brassavolaperrine)* and a hybrid [(*Laelia cattleya* Culminant "Tuilerie" x *Laelia cattleya* Sons Atout Rotunda) x *Brassolaelia cattleya* Startifire Moon Beach], checked, for the native species, the greater length of the plant using 0.5 mg L^{-1} of calcium silicate, reaching a maximum of 7.1 cm under red artificial light.

In an experiment with orchid growth under black screenhouse with 50% shading, Schnitzer et al. (2015) evaluated the effect of different pyroligneous extract doses in *C. loddigesii* Lindl growing and found that, as increased the pyroligneous extract doses, greater heights of shoots occurred. Schnitzer et al. (2010), evaluating the vegetative growth of two species of Brazilian orchids, *C. intermedia* Lindl. and *Milt clowesii* Lindl., using different substrates and fertilization with addition of pyroligneous extract up to 220 days under shading screen with 70% of luminosity, verified average height of 11.6 cm for *Milt clowesii* and 14.7 for *C. intermedia*. In this study, the same trend was found, showing the beneficial effect on the vegetative growth of the studied species, being an alternative for plant nutrition.

With regard to plant height and leaf number under Black Cromatinet with 50% of shading, the fertilization with addition of nutritive solution shows a linear and positive effect (Figure 4A) in the deployment of interaction between the factors for the three substrates.

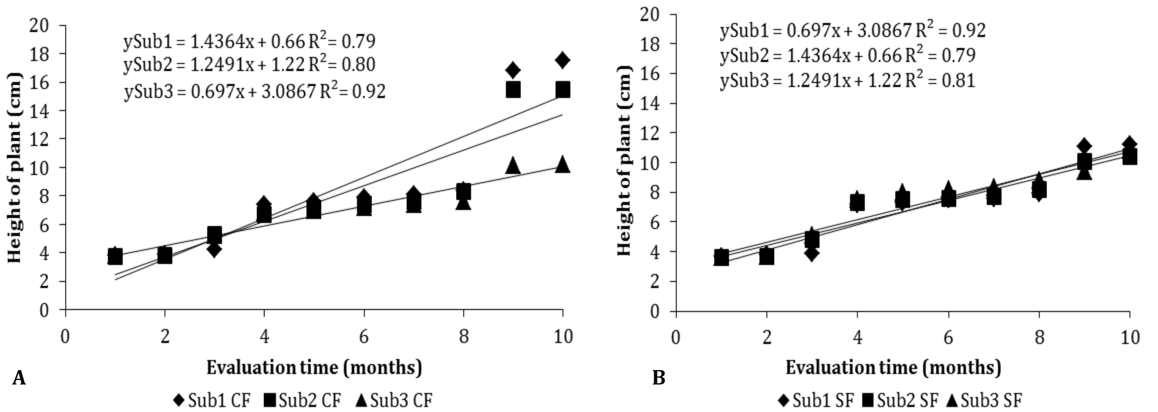

Figure 4. Plant height of *Cattleya eldorado* plants grown on substrates of crushed cupuaçu peel (sub1), industrialized coconut fiber (sub2), blend of 50% sub1 and 50% of sub2 (sub3) obtained (A) with the addition of nutritive solution (CF), and (B) without addition of nutritive solution (SF) along 300 days under black Cromatinet screen.

Yamakami et al. (2006), in experiments with *Cattleya* hybrids on different substrates under black screenhouse with 50% shading, reported better results for plant height with the use of coconut fiber and pure pine bark or in combination with carbonized rice husk.

Similarly, in the deployment of the interaction between substrate 1 (crushed cupuaçu peel) and fertilization with addition of nutritive solution, the number of leaves showed, in the present research, a linear and positive effect (Figure 5A).

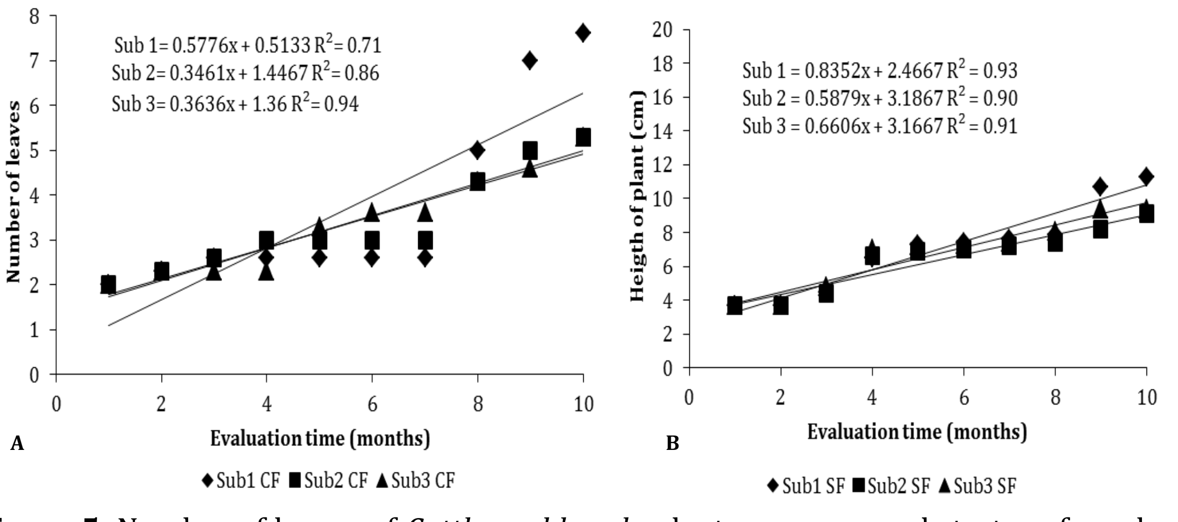

Figure 5. Number of leaves of *Cattleya eldorado* plants grown on substrates of crushed cupuaçu peel (sub1), industrialized coconut fiber (sub2), blend of 50% sub1 and 50% of

sub2 (sub3) obtained (A) with the addition of nutritive solution (CF), and (B) without addition of nutritive solution (SF) along 300 days under black Cromatinet screen.

No significance was found to differentiate the triple interaction between shading x substrate x fertilization with addition of nutritive solution for the variables height, number of leaves and chlorophyll a and b contents. However, there was effect of the substrate in the cultivation of *C. eldorado* fertilization with and without addition of nutrient solution, regardless of the shading screens (Table 4). There was no shade screen effect on plant height, number of leaves and chlorophyll a and b contents.

The results obtained from this research corroborate those obtained by Melo et al. (2009) and Costa et al. (2011). They evaluated the effect of solar radiation altered by red coloration screen with 35% shading and black coloration screen with 50% shading on the aspects of vegetative growth of *Catharanthus roseus* (L.) plants and strawberry plants, respectively. It was not foundsignificant interaction, showing that factors acted independently. Thus, it is understood that the effect of the irradiance is more prominent than the spectral changes on this variable in the studied species.

The leaf chlorophyll content is positively correlated with fertilization by addition of nutritive solution, there was increase in content of chlorophyll a and b (Table 3) as well, it has the highest growth rate in height of the seedlings (Figure 3B).

Data showed that, in general, the development of plants of *C. eldorado* was favored with the use of fertilization by addition of nutritive solution, indicating the importance of fertilization use in the orchid cultivation (Wang, 2010). Figueiredo and Kolb (2013) highlighted that the choice of suitable substrate can also encourage the growth of these plants.

Table 3. Plant heigth (cm), number of leaves and chlorophyll a and b content of *Catlleya eldorado* seedlings grown on different substrates: crushed cupuaçu peel (sub1); industrialized coconut fiber (sub2); blend of 50% sub1 and 50% of sub2 (sub3), obtained with addition of nutritive solution (CF) and without addition of nutrient solution (SF) under black Cromatinet screens at 300 DAT

Substrates	Height	Number of Leaves	Clorophyll a	Clorophyll b
		With fertilization		
Sub1	16.5 aA	6.8 aA	39.7 aA	16.9 aA
Sub2	13.2 bA	4.5 aA	36.1 aA	11.1 bA
Sub3	12.7 bA	6.5 aA	34.3 aA	11.5 bA
Mean	14.1	5.9	36.7	13.2
		Without fertilization		
Sub1	11.3 aB	4.2 aB	32.2 aB	9.1 aB
Sub2	9.8 aB	3.8 aA	30.6 aB	7.5 aB
Sub3	10.1 aA	3.8 aB	30.0 aA	8.3 aB
Mean	10.4	3.9	30.9	8.3
CV %	18.4	36.9	11.5	18.2

* Means followed by the same lowercase letters in the column and uppercase letters in the line do not differ by Tukey's test with a P-value of 5%.

Is worth noting that they were not identified symptoms of disease attack, pests and nutritional deficits during the 300 DAT, demonstrating that the substrates with addition of nutritive solution were effective on nurturing in a balanced way and to establish plants in the tested conditions. In addition, there was 100% survival of orchids, regardless of the tested substrate.

Conclusions

Fertilization by addition of nutritive solution promotes growth in height and leaf number, also results in higher levels of chlorophyll a and both under red as black Cromatinet. The addition of nutritive solution is indicated for the cultivation of *Cattleya eldorado* seedlings.

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