SILVA, B. L. B.; SOUZA, V. C. M.; COSTA, E.; SILVA, A. G.; BINOTTI, F. F. S.; CAVALCANTE, D. F.; BENETT, C. G. S; ZOZ, T. Reflective materials and seeds from different plant positions for production of achachairu seedlings. **Revista de Agricultura Neotropical**, Cassilândia-MS, v. 8, n. 1, e5709, jan./mar. 2021. ISSN 2358-6303. DOI: https://doi.org/10.32404/rean.v8i1.5709.

Revista de Agricultura Neotropical

Reflective materials and seeds from different plant positions for production of achachairu seedlings

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Received: 30/11/2020; Accepted: 21/01/2021.

ABSTRACT

The plant environment in the production of Achachairu (*Garcinia humilis*) seedlings aims to obtain quality plants for orchards' formation. The present study aimed to evaluate reflective materials on benches and fruit seeds harvested from different plant positions to produce Achachairu seedlings. The reflective materials used under the cultivation benches were aluminum foil, "fake sequin" fabric, mirror, and tetra pak®. The fruit collection positions in the plants were at the top, median and bottom. The largest seedlings were obtained on the bench with reflective material of Tetra Pak®; however, in this material, there was a greater relationship between the height and diameter of the seedlings' neck, which is not desired for quality seedlings. The largest number of sheets was observed on the benches with reflective material of Tetra Pak® and "false sequin" fabric. The lowest dry masses of the root system and the lowest Dickson quality indexes were obtained from seedlings grown on the bench with reflective mirror material, forming lesser quality seedlings. The fruit collection place in the matrix plant did not influence the seedlings' quality. The use of reflective material on the bench is not recommended for the cultivation of Achachairu seedlings.

Keywords: *Garcinia humilis*, aluminum foil, "fake sequin" fabric, mirror, Tetra Pak®.

Materiais refletivos e sementes de diferentes posições na planta para produção de mudas de Achachairu

RESUMO

A ambiência vegetal na produção de mudas de Achachairu (*Garcinia humilis*) visa obter plantas de qualidade para a formação de pomares. O objetivo do presente estudo foi avaliar materiais refletivos em bancadas e sementes de frutos colhidos em diferentes posições na planta para produção de mudas de achachairu. Os materiais refletores utilizados sob as bancadas de cultivo foram o papel alumínio; tecido "falso paetê"; espelho e tetra pak®. As posições de coleta dos frutos nas plantas foram na parte superior, mediana e inferior. As maiores mudas foram obtidas na bancada com material refletivo de tetra pak®, no entanto, nesse material verificou-se a maior relação entre a altura e diâmetro do colo das mudas, o que não é desejado para mudas de qualidade. O maior número de folhas foi observado nas bancadas com material refletivo de tetra pak® e tecido "falso paetê". As menores massas secas do sistema radicular e os menores índices de qualidade de Dickson foram obtidos nas mudas cultivadas na bancada com material refletivo de espelho, formando as mudas de menor qualidade. O local de coleta do fruto na planta matriz não influenciou a qualidade das mudas. Não se recomenda o uso de material refletor em bancada para o cultivo de mudas de achachairu.

Palavras-chave: *Garcinia humilis*, papel alumínio, tecido de "falso paetê", espelho, Tetra Pak®.

1. Introduction

Brazil is an important world fruit producer with an expressive exotic fruit production adapted to its climate. Achachairu (*Garcinia humilis*) is an exotic fruit native from Bolivia (Barbosa et al., 2008) that has been produced and marketed in Brazil, especially in the northeastern states (Barbosa and Artioli, 2007; Melo et al. 2017). To implement or renovate orchards, information on high-quality seedlings production is necessary (Silva et al., 2018b).

In the Brazilian northeast, the *Garcinia humilis* fruit maturation occurs from February to April (Barbosa and Artioli, 2007), and in the Cerrado region (Ipameri-GO; Paranaíba-MS) the maturation was verified from October to November (Silva et al., 2018). In addition to the possibility of using the Achachairu to form orchards in cerrado regions, the high-quality seedlings of this species can be used in landscaping, degraded and deforested areas recovery, protection of springs, forest formation, reforestation, among others (Silva et al., 2018a; Silva et al., 2018b).

High-quality seedlings production involves studies of plant environment, commercial and alternative substrates, commercial and biodegradable containers, irrigation methods, nutrition, sowing times, among others. Recent studies on reflective material in cultivation benches use in the plant environment aim to increase the supply of photosynthetically active radiation to abaxial leaves and improve plants' photosynthetic efficiency.

The use of a mirror as a reflective material for yellow passion fruit seedlings (*Passiflora edulis* Sims. F. Flavicarpa Deg) resulted in a higher growth rate and dry matter accumulation in the aerial part than the use of reflective tissue (Santos et al., 2017). The mirror also produced baruzeiro seedlings (*Dipteryx alata)* better than the control system (Costa et al., 2020). Better jambolan (*Syzygium cumini*) seedlings in screened environments with 30% shading were obtained with the use of reflective material (aluminum foil) on the cultivation bench (Salles et al., 2017). Similarly, aluminum foil's positive influence on *Carica papaya* seedlings' quality (Cabral et al., 2020) and *Schizolobium amazonicum* seedlings grown in a protected environment (Mortate et al., 2019) has been reported.

For achachairu, no information was obtained on the influence of seeds from different plant positions on the quality of seedlings since seeds are generally obtained from fruits collected after their detachment. For chili peppers (*Capsicum frutescens*), seeds collected from the plant's basal part showed greater vigor, providing better initial seedling development, with longer root length, fresh and dry mass (Mengarda and Lopes, 2012).

The study aimed to evaluate the formation of *Garcinia humilis* seedlings on benches with different reflective materials and seeds collected from fruits from different plant positions.

2. Material and Methods

The experiment was conducted at the State University of Mato Grosso do Sul (UEMS), Cassilândia-MS University Unit, latitude -19.1225º (= 19º07'21" S), longitude -51.7208º (= 51º43'15" W) and altitude of 516 m (Automatic station CASSILANDIA-A742), from November 2016 to May 2017. A protected environment was used, consisting of an agricultural screen, with a galvanized steel structure, with 8.00 m wide per 18.00 m long and 3.50 m high, closing at 45º of inclination, with monofilament mesh in its entire length and mesh with 50% shading (Silva et al., 2018a).

The experiment was carried out in a completely randomized design, in a 5 x 3 factorial scheme (four benches with reflective material plus the control x three fruit collection positions on the plant), with five replicates and five plants per plot. The reflective materials used under the cultivation benches were aluminum foil, “fake sequin” fabric, mirror, and Tetra Pak® (Figure 1). The plants’ fruit collection positions were in the upper (apical), median and lower (basal) parts.

Sowing took place on November 5, 2016, with two seeds per polyethylene bag with a capacity of 1.8 L, and later thinning was carried out. The containers were placed on the cultivation bench at 3 x 3 cm spacing (Figure 2). The substrate composed of bovine manure mixture, Bioplant®, washed fine sand, and superfine vermiculite (Silva et al., 2018a) was used, maintaining its humidity by daily manual irrigation.

At 180 days after sowing (DAS), plant height (PH), stem diameter (SD), number of leaves (NL), dry mass of the aerial part (DMAP), and the dry mass of the root system (DMRS) were collected. From these variables, the total dry mass (TDM) was determined by adding DMAP and DMRS, the relationship between PH and SD (HDR), the relationship between DMAP and DMRS (DMR), the relationship between PH and DMAP (HMR), and the Dickson Quality Index (DQI).

The PH measurement was performed with a graduated ruler (cm), measuring the distance from the plant's stem to the apex. SD was measured with a digital caliper (mm). The NF was determined by counting. DMAP and DMRS (g) were obtained on an analytical balance after being dried in a stove with forced air circulation, at 65º C, for 72 hours.

Figure 1. Benches preparation for seedling production. (A) Tetra Pak®. (B) Fake Sequin Fabric. (C) Aluminum foil. (D) Mirror.

Figure 2. Spacing between polyethylene bags.

At 10 am, the reflected photosynthetically active radiation (micromol/m^2.s) of each material (treatment) was collected, with the sensor facing downwards at an average distance of 20 cm from the reflective material.

Also, the incident photosynthetically active radiation (micromol/m^2.s) inside and outside the protected environment, with the sensor facing upwards, being measured with Apogee brand equipment model MP-200. Each collection month, from November to May, a block (one repetition) was considered to statistically compare the reflected photosynthetically active radiation (micromol/m^2.s) data, totaling seven repetitions.

Inside the environment (screened), no micrometeorological data were collected, as there were no sensors available. Outside the cultivation environment, the maximum (Tmax) and minimum (Tmin) air temperature, maximum (RHmax), and minimum (RHmin) air relative humidity, precipitation, and global solar radiation (GSR) were obtained through station A742 - Cassilândia (INMET). GSR was considered between 9 am and 4 pm, Brasilia time zone (Figure 3). The data were submitted to analysis of variance, and when significant, the averages were compared using the Tukey test.

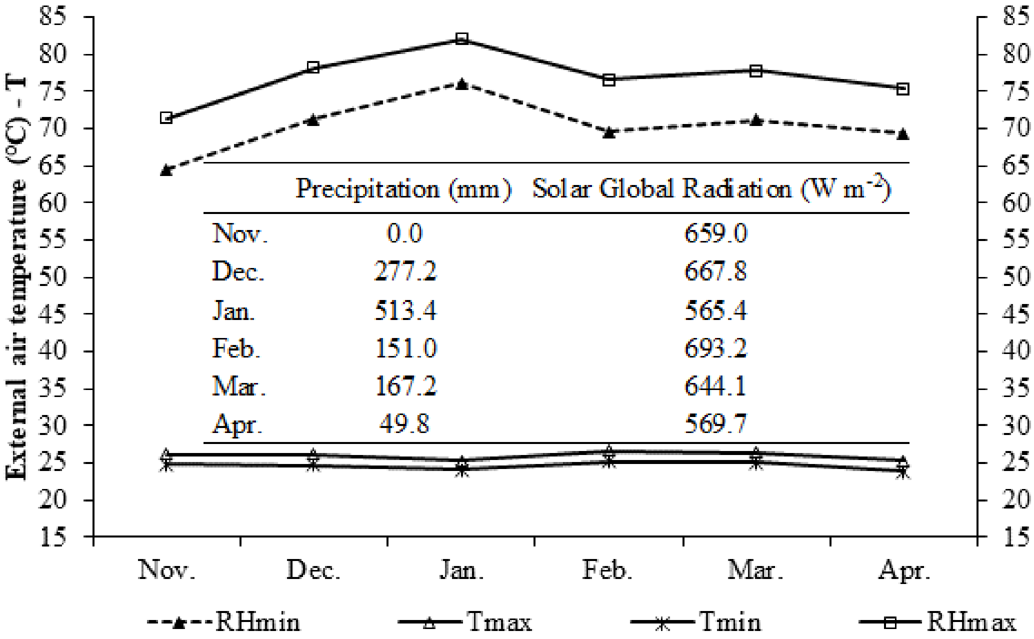

Figure 3. Maximum (Tmax) and minimum (Tmin) temperature, maximum (RHmax), and minimum (RHmin) relative air humidity, precipitation, and global solar radiation (GSR).

3. Results and Discussion

There was no significant interaction between the reflective material type on the cultivation bench and the fruit collection plant's position to produce achachairu seedlings. There was a significant difference between the cultivation bench's reflective materials in seedling formation for the other variables, except for the ratio between DMAP and DMRS (DMR). The plant's fruit collection position showed a significant difference in seedling formation only for the number of leaves (NL) (Table 1).

The use of reflective material on the bench for cultivation did not influence the achachairu seedlings' quality. The best results in these materials did not differ from the control bench (without reflective material), especially the phytomass and Dickson quality index (Table 2). These results differ from those obtained by Santos et al. (2017), Salles et al. (2017), Mortate et al. (2019), and Costa et al. (2020) that verified the positive influence of the reflective material on the seedlings' quality. The dwelling time of the achachairu seedlings in the nursery (180 days) may have negatively influenced the reflective material use.

The largest seedlings (PH) were obtained on the bench with reflective material of Tetra Pak®; however, the highest relationship between the height and diameter of the seedling stem (HDR) was found in this material, which is not desired for quality seedlings (Table 2). According to Gomes and Paiva (2012), the HDR is an indicator of the seedling's quality, as it presents the growth balance between height and diameter. On the other hand, Carneiro (1995) reports that the smaller this value is, the lower the seedlings' possibility to stagnate. The largest seedlings' stem diameters (SD) were verified in the countertops and "fake sequins" fabric, and the largest number of leaves (NL) was observed in the countertops with reflective Tetra Pak® material and "fake sequins" fabric (Table 2). The positive influence of the "fake sequin" fabric on the seedling characteristics is observed in both variables, a material not indicated for passion fruit seedlings production (Santos et al., 2017).

The seedlings' aerial part (DMAP) and total (TDM) dry masses observed in the bench covered with a mirror did not differ from the bench with aluminum foil showing lower values than those observed in the other treatments. The lowest root masses (DMRS) and Dickson quality indexes (DQI) were observed for these two materials forming the lowest quality seedlings (Table 2). These achachairu's 180-day results differ from those obtained by Santos et al. (2017) for passion fruit at 70 days and by Costa et al. (2020) for the baruzeiro at 80 days, that observed a positive influence on the seedlings grown on the bench with a mirror. The length of time the seedlings remain in the nursery and the greater heating promoted by the mirror probably interfere with the achachairu seedlings' quality characteristics.

It was possible to verify through the variables NL, SD, DMAP, DMRS, and DQI that the fake sequin fabric provided high-quality seedlings. This finding diverges from the results found by Santos et al. (2017), who do not recommend using this reflective material on the bench for the formation of passion fruit seedlings.

Table 1. Analysis of variance with the calculated F and coefficient of variation (CV) of plant height (PH), stem diameter (SD), number of leaves (NL), dry mass of the aerial part (DMAP), dry mass of the root system (DMRS), total dry mass (TDM), ratio between PH and SD (HDR), ratio between DMAP and DMRS (DMR), ratio between PH and DMAP (HMR) and Dickson quality index (DQI).

	PH	SD	NL	DMAP	DMRS
Reflective material on the bench (MB)	**	*	**	**	**
Fruit position on the plant (FP)	ns	Ns	**	ns	ns
MB x FP	ns	Ns	Ns	ns	ns
CV	12.02	7.09	11.64	25.7	27.81
	TDM	HDR	DMR	HMR	DQI
Reflective material on the bench (MB)	**	**	Ns	*	**
Fruit position on the plant (FP)	ns	Ns	Ns	ns	ns
MB x FP	ns	Ns	Ns	ns	ns
CV	21.82	11.14	32.16	25.2	22.86

** significant at 1%; * significant at 5%; ns = not significant; CV = variation coefficient.

Table 2. Plant height (PH), stem diameter (SD), number of leaves (NL), dry mass of the aerial part (DMAP), dry mass of the root system (DMRS), total dry mass (TDM), ratio between PH and SD (HDR), ratio between DMAP and DMRS (DMR), ratio between PH and DMAP (HMR) and Dickson quality index (DQI) int the cultivation benches materials, at 180 DAS.

Material on cultivation bench	PH	SD	NL	DMAP	DMRS
Control	10.68 c	2.09 a	4.59 b	0.53 a	0.26 a
Aluminum foil	11.13 c	2.00 b	4.37 b	0.48 b	0.23 a
Tetra pak®	13.65 a	1.97 b	4.99 a	0.59 a	0.29 a
Mirror	11.07 c	1.98 b	4.13 b	0.42 b	0.19 b
Fake Sequin Fabric	12.19 b	2.09 a	5.20 a	0.58 a	0.24 a
Material on cultivation bench	TDM	HDR	DMR	HMR	DQI
Control	0.79 a	5.12 c	2.14 a	21.05 b	0.111 a
Aluminum foil	0.72 b	5.56 b	2.16 a	24.37 a	0.093 a
Tetra pak®	0.88 a	6.96 a	2.10 a	24.80 a	0.097 a
Mirror	0.61 b	5.61 b	2.45 a	27.97 a	0.077 b
Fake Sequin Fabric	0.83 a	5.82 b	2.56 a	21.95 b	0.100 a

Means followed by the same letter in the column for each variable do not differ by the Tukey test at 5% probability.

Among the reflective materials, the lower quality seedlings were checked on the bench covered with a mirror (Table 2), which, even expanding the supply of photosynthetically active radiation (Figure 2), probably promoted greater substrate heating, thus hampering the seedlings root development. These results of the greater radiation reflected by the mirror agree with Santos et al. (2017); however, those authors found better passion fruit seedlings for this material, differing from the current study results.

The influence of seeds from different positions on the plant on the seedlings' quality of achachairu was not verified (Table 3) since the seeds generally used to form seedlings are obtained from fruits collected after their detachment (Silva et al., 2018 a, b). For chili peppers (*Capsicum frutescens*), seeds collected from the plant's basal part showed greater vigor, resulting in better initial seedling development, with longer root length, fresh and dry mass (Mengarda and Lopes, 2012), diverging from the results obtained in the current study.

It is observed that the distribution of aerial and root dry phytomass follows a proportion, on average, from 68% to 32%. That is, of the total phytomass of the achachairu seedlings, 68% belongs to the aerial part, and 32% to the root system, independently of the reflective material on the bench and the position of the mature fruit on the plant. This evidences that the treatments of vegetal ambiance (reflective material and fruits' collection place in the plant) applied to the achachairu seedlings' formation. It practically maintains a ratio of 1 to 2 in the distribution of photoassimilates between the seedlings' aerial and root part, meaning that the aerial part phytomass is twice the large of the root part (Figure 4).

The internally incident photosynthetically active radiation (FAR) in the cultivation environment was, on average, 36.7% of the external one (Figure 5), similar to that observed by Silva et al. (2018a), which obtained 37.6%. Thus, it was observed that the black monofilament mesh over the entire extension of the cultivation environment, mesh with 50% shading, prevents the passage of 63.3% of the FAR. The mirror provided the highest RFA reflectance (Figure 6); however, this higher radiation level available to the seedlings did not improve the photosynthetic gain nor higher seedlings quality.

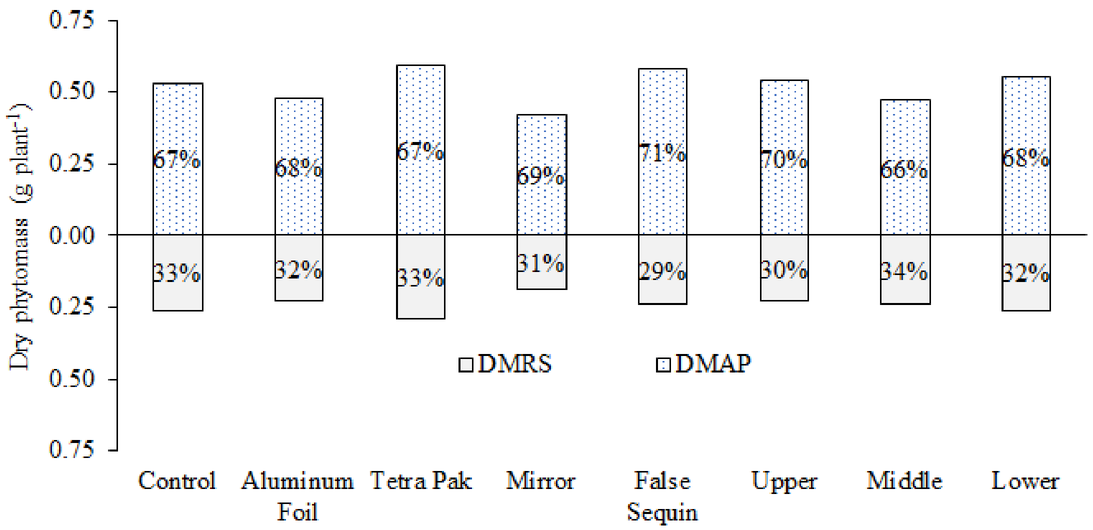

Figure 4. Distribution of dry aerial (DMAP) and root (DMRS) phytomass from the achachairu seedlings in the control cultivation benches, aluminum foil, Tetra Pak® wrapping, mirror and in the fake sequin fabric, as well as in the upper, middle, and lower fruit position in the plant at 180 DAS.

Table 3. Plant height (PH), stem diameter (SD), number of leaves (NL), shoot dry matter (DMAP), root system dry mass (DMRS), total dry mass (TDM), ratio between PH and SD (HDR), ratio between DMAP and DMRS (DMR), ratio between HP and DMAP (HMR) and Dickson quality index (DQI) in the fruit position in the plant, 180 DAS.

Fruit position in the plant	PH	SD	NL	DMAP	DMRS
Superior	12.02 a	2.05 a	4.95 a	0.54 a	0.23 a
Median	11.34 a	1.98 a	4.37 b	0.47 a	0.24 a
Lower	11.86 a	2.05 a	4.65 b	0.55 a	0.26 a
Fruit position in the plant	**TDM**	**HDR**	**DMR**	**HMR**	**DQI**
Superior	0.77 a	5.87 a	2.45 a	23.66 a	0.094 a
Median	0.71 a	5.78 a	2.08 a	25.41 a	0.092 a
Lower	0.81 a	5.79 a	2.32 a	23.02 a	0.101 a

Means followed by the same letter in the column for each variable do not differ by the Tukey test at 5% probability.

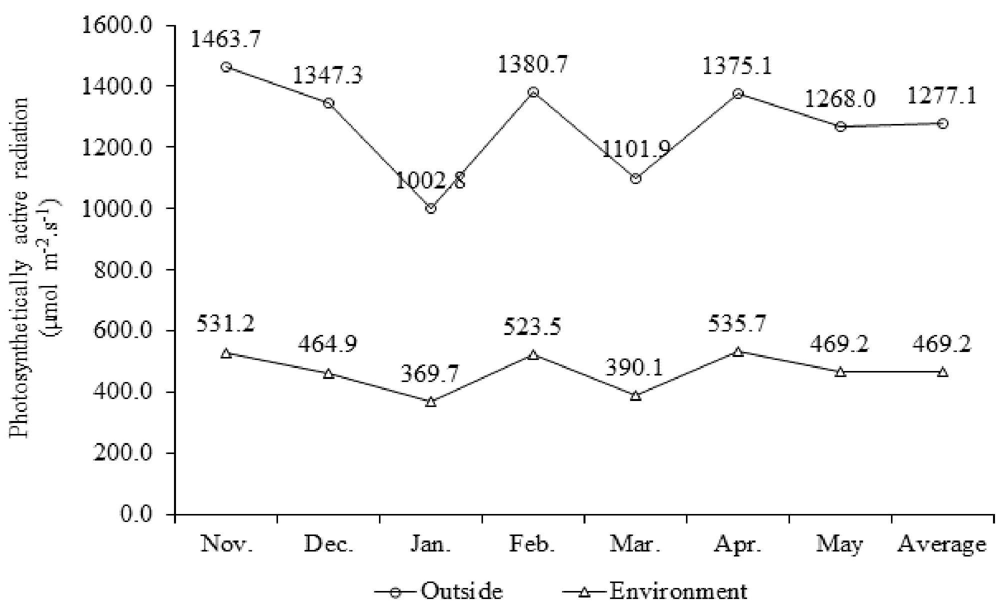

Figure 5. Photosynthetically active radiation incident outside and in the cultivation environment (micromol.m^{-2}.s^{-1}). Cassilândia-MS, 2017.

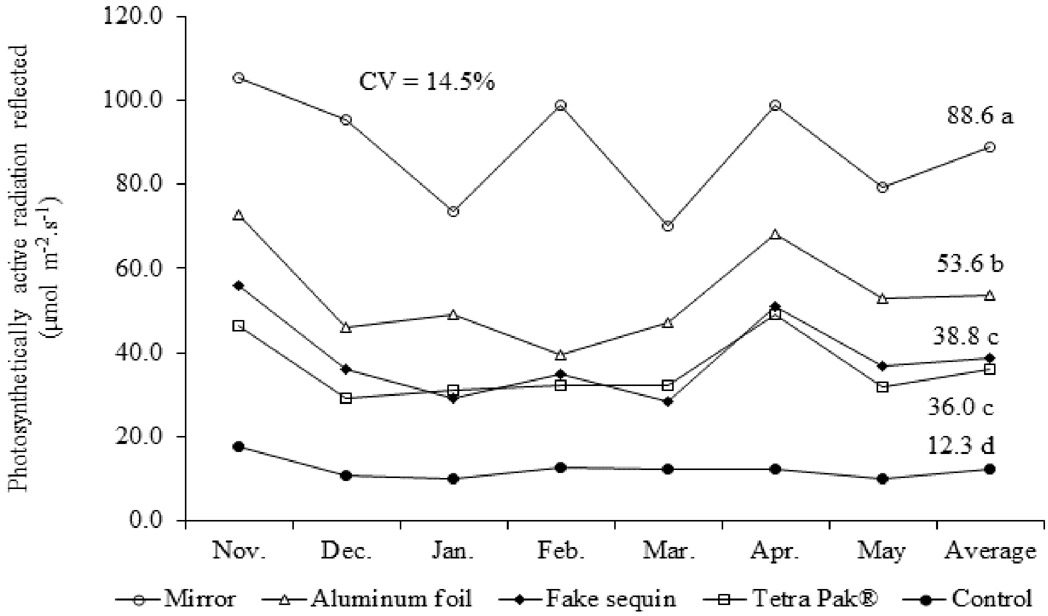

Figure 6. Photosynthetically active radiation reflected in the materials of the cultivation bench (micromol.m^{-2}.s^{-1}). Means followed by the same lowercase letters do not differ by the Tukey test at 5% probability. CV = coefficient of variation. Cassilândia-MS, 2017.

In the current study, it was obtained that 68% of the total achachairu seedlings' phytomass belongs to the aerial part and 32% to the root system. These results diverge from the results presented by Silva et al. (2018b), who obtained 46% aerial and 54% root, as well as Silva et al. (2018a), who observed 55% aerial and 45% root.

4. Conclusions

The fruit collection place in the matrix plant did not influence the seedlings.

The use of reflective material on the bench for cultivation did not influence the quality of seedlings of achachairu.

Authors' Contribution

Bruna Luzia Barbosa da Silva contributed to setting up the experiment, collecting data, and writing the manuscript. Vitória Cristina Di Matheus e Souza contributed to creating the figures and writing the manuscript. Edilson Costa contributed to statistical analysis, creating the figures, and writing the manuscript. Abimael Gomes Silva contributed to statistical analysis, creating the figures, and writing the manuscript. Flavio Ferreira da Silva Binotti contributed to writing the manuscript. Daniele Ferreira Cavalcante contributed to writing the manuscript. Cleiton Gredson Sabin Benett contributed to the seeds collection and writing the manuscript. Tiago Zoz contributed to statistical analysis, and writing the manuscript.

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