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Vermiculite in the initial development of coffee seedlings in different containers

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Abstract. *Coffea arabica* L. is responsible for 81% of the coffee cultivation area in Brazil and has great economic and social importance in the regions it is cultivated. Producing vigorous seedlings in a short period of time has become an increasing challenge in coffee growing. Thus, the objective of this study was to evaluate the initial development of seedlings produced in bags and polyethylene tubes with different levels of vermiculite. A 2x5 factorial scheme was used; the factors were: two containers: polyethylene bags (containing standard substrate, subsoil and manure (7:3) and tubes (commercial substrate based on pine bark) and addition of vermiculite, at levels 0%, 10%, 20%, 30% and 40%. In each type of substrate, the respective amounts of vermiculite were added. The variables analyzed were shoot height, root length, stem diameter, number of leaf pairs, shoot and root fresh and dry matter. Based on the results obtained, it was observed that the seedlings produced in polyethylene bags showed higher significant averages for all evaluated parameters, showing greater vigor and initial development than seedlings produced in tubes. The seedlings produced in bags responded positively to the increase in vermiculite for all analyzed parameters, whereas those produced in tubes show the opposite behavior.

Keywords: Polyethylene bags; Tubes; Seedling production; coffee growing.

Introduction

Coffee is one of the most economically and culturally important crops in Brazil and worldwide. It is a plant of the Rubiaceae family, of the genus *Coffea* L., which has 104 classified species, and those most commercially important are: *C. arabica* L. and *C. canephora* (Sakiyama et al., 2015). Arabica coffee (*Coffea arabica* L.) is the most cultivated species of its genus in the world (Davis et al., 2019). Brazil is the largest coffee producer in the world, with 81% of the total area of the species in the country cultivated with arabica coffee (Companhia Nacional de Abastecimento, CONAB, 2019).

The Arabica coffee plant is a perennial shrub, and its reproduction is considered autogamous, due to its low percentage of cross-fertilization. The fact that it is autogamous makes the use of seedlings

produced by seeds highly viable, since it guarantees the genetic quality and uniformity of the crop (Sakiyama et al., 2015).

The use of healthy and vigorous seedlings is directly related to productive success and crop longevity (Pereira et al., 2017). Among the containers used for the production of Arabica coffee seedlings, the most used are polyethylene bags with conventional substrate produced from gully soil, tanned cattle manure and correction with mineral fertilizer. However, the use of tubes has been gaining ground in the production of coffee seedlings, mainly due to the practicality and optimization of space in nurseries and, in this case, the most common substrates are commercial, based on pine bark (Tomaz & Rodrigues., 2015).

The main characteristics that a container must have are: low cost, easy handling and a format that allows a good development of the seedling root system. In the case of the substrate, it is essential that it presents a good balance between its physicochemical characteristics, in order to provide a favorable environment for seedling development (Dias et al., 2009).

Gully soils have good chemical activity, but their structure depends on the clay content of the soil used by the nurseryman; medium-textured soil is recommended. The commercial substrates used in seedlings produced in tubes, have low CTC and water retention, which causes a more complex management of nutrient supply and increased attention in irrigation. Due to physical and chemical requirements, for the substrate to meet the demands of the soil-plant-environment system within the nursery, there is a mineral that has the ability to directly change these characteristics. Vermiculite is a low-cost and easy-to-handle mineral, capable of improving the physical characteristics of the soil, in addition to retaining water and nutrients (Martins et al., 2012). Despite its use in other areas, in coffee growing, there are few studies that evaluate levels of expanded vermiculite in isolation as a component of the substrate.

Given the above, the objective of this study was to evaluate the initial development of seedlings produced in polyethylene bags and tubes with different levels of vermiculite.

Material and Methods

The experiment was conducted in a greenhouse at Federal University of São João del Rei (UFSJ), Sete Lagoas campus - MG. A randomized block design (RBD) was used, in a 2 x 5 factorial scheme, with 4 replications, and each plot was surrounded by border seedlings (12 seedlings), considering the 4 central seedlings as a useful area for evaluations.

The treatments consisted of 0, 10, 20, 30 and 40% (volume) of vermiculite expanded by conventional substrate used in polyethylene bags and tubes % (V/V). The polyethylene bags used had a volume of 700 mL, and the tubes, 380 mL.

The substrate used in the bags was made in the proportion of 700 L of sieved subsoil, 300 L of tanned cattle manure and mineral correction with 4 kg of single superphosphate, 750 g of potassium chloride and 1.5 kg of dolomitic limestone (Tomaz & Rodrigues, 2015). In the tubes, a commercial substrate Bioplant®, based on pine bark, was used.

Before sowing, the parchment was removed from the seeds. Sowing was carried out on 06/20/2018, directly in the containers used, with three seeds in each one, at a depth of 20mm. The cultivar used was IAC 125 RN. Thinning was done when the seedlings were in the jaguar ear stage, leaving only one plant. During the experiment, ammonium sulfate was applied every 15 days, at a dose of 30g for every 200 seedlings, via fertigation from the first pair of real leaves (Brilho et al., 1964).

The evaluations were made 150 days after sowing (DAS), namely: Shoot Height (SH), Stem Diameter (SD), Root Length (RL), Number of Leaf Pairs (NLP), Shoot Fresh Matter (SFM), Root Fresh Matter (RFM), Shoot Dry Matter (SDM), Root Dry Matter (RDM).

To carry out the evaluations, the seedlings were removed from the containers and the substrate was washed, in order to preserve its roots, and taken to the laboratory for the respective measurements. In the evaluation of the number of leaf pairs, only pairs with fully expanded leaves were considered. The shoot was measured from the stem base to its apical bud and the length of the root system was measured from the stem base to the end of the root completely extended, both with the aid of a ruler. Stem diameter was measured just below the insertion of the cotyledonary leaves "jaguar ear", with a digital caliper. Shoot and root fresh matter were weighed with the aid of a precision scale. Shoot and root dry matter were obtained as follows: the sectioned plant parts for each replication were packed in paper bags and taken to a greenhouse at 65°C for 72 hours, after which they were successively weighed with the aid of a precision scale until the results stabilized and, thus, the average shoot and root system were obtained.

The variables studied were subjected to analysis of variance by the F test, and the means were compared to the Tukey test for the qualitative factor, and regression analysis for the quantitative, at 5% probability, using the SISVAR® software (Ferreira, 2010).

Results and discussion

In Table 1, it can be observed that there was a significant interaction between the levels of vermiculite and containers for Shoot Height (SH) and Number of Leaf Pairs (NLP). Root Length (RL) showed no interaction between the factors, but there was a significant difference between the levels of vermiculite and between containers. Stem diameter (SD), however, showed a significant difference only between containers.

For Shoot Height (SH), in seedlings produced in bags, this parameter tended to show higher values as there was an increase in the percentage of vermiculite, whereas the result was the opposite in the tube (Figure 1). In a study with *Coffea arabica* L. seedlings, Vallone et al. (2009) observed that the means for shoot height and dry matter of seedlings were also higher in bags with standard substrate in relation to tubes with commercial substrate; this performance was associated with the volume difference between the containers, since the conventional polyethylene bags have 700mL and the tube volume used in their study was 120mL. That result also corroborated those found in this study, where the bags used had 700mL of volume and the tubes 380mL.

Table 1. Analysis of variance for shoot height (SH), root length (RL), stem diameter (SD), number of leaf pairs (NLP), for *Coffea arabica* L. seedlings, produced in polyethylene bags and tubes.

FV	DF	Mean Squares			
		SH (cm)	RL (cm)	SD (mm)	NLP
Container (C)	1	36.3856**	440.8960**	7.0791**	25.6000**
Vermiculite (V)	4	0.4660ns	5.4004*	0.0148 ns	0.0664 ns
C x V	4	0.8803*	2.8188 ns	0.08932 ns	0.9633**
Block	3	0.1434	4.1892	0.0725	0.0500
Residue	27	0.2499	1.4601	0.0335	0.1345
CV (%)		7.64	5.94	8.02	22.57
General Mean		6.54	20.34	2.28	1.62

** , * e ns: Significant at 1%, 5% and not significant, respectively, by the F test.

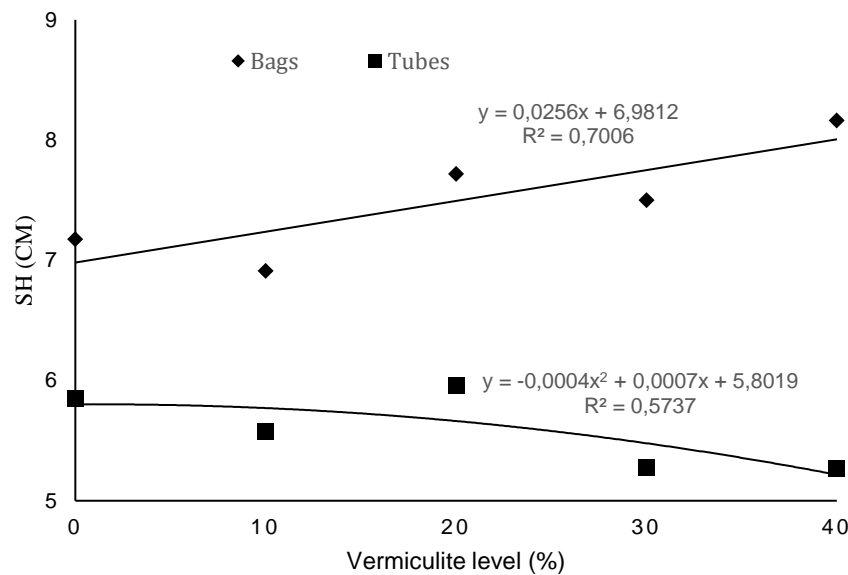


Figure 1. Shoot height (SH) (cm), as a function of vermiculite levels for *Coffea arabica* L. seedlings, produced in polyethylene bags and tubes.

The means for root length (RL) and stem diameter (SD) were higher in seedlings produced in bags (Table 2). A longer root length was observed as the level of vermiculite increased, regardless of the container used (Figure 2). Kratz et al. (2015) also observed this behavior in a study with yerba mate, assigned to the water/aeration balance in the substrate, caused by the addition of vermiculite.

For NLP, the seedlings produced in bags also showed an increase in the level of vermiculite, with a more significant increase from 20% of vermiculite in the substrate, whereas the seedlings produced in the tube showed the opposite behavior (Figures 3). In studies with eucalyptus seedlings, Caldeira et al. (2013) observed that the increase in vermiculite levels in the substrate had a positive effect on the morphological characteristics of the plants, the same trend observed in the bag seedlings.

Table 2. Mean Root Length (RL) and Stem Diameter (SD), for *Coffea arabica* L. seedlings, produced in polyethylene bags and tubes.

Container	RL (cm)	SD (mm)
Bag	23.66 a	2.70 a
Tube	17.02 b	1.86 b

Means followed by different letters in the column differ by the Tukey test at 5% probability.

There was a significant interaction between the levels of vermiculite and containers for Shoot Fresh Matter (SFM), Root Fresh Matter (RFM), Shoot Dry Matter (SDM) and Root Dry Matter (RDM) (Table 3).

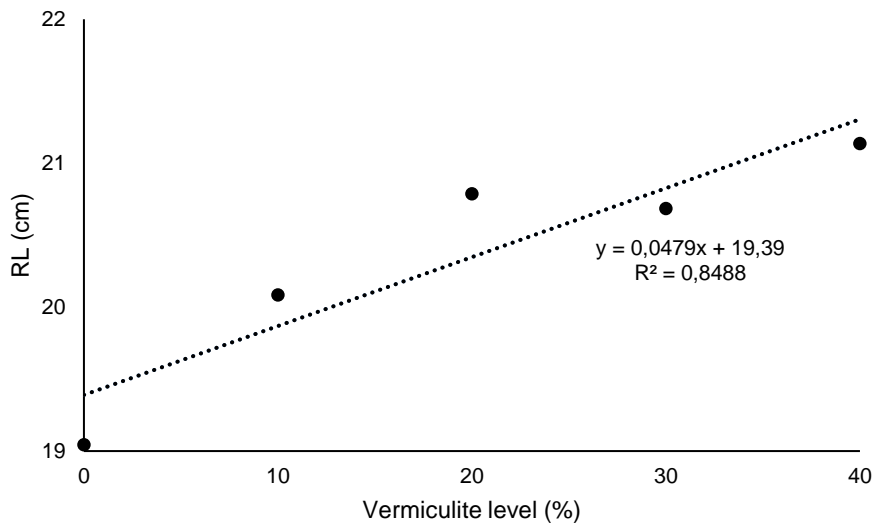


Figure 2. Root Length (RL) of *Coffea arabica* L. seedlings as a function of vermiculite levels.

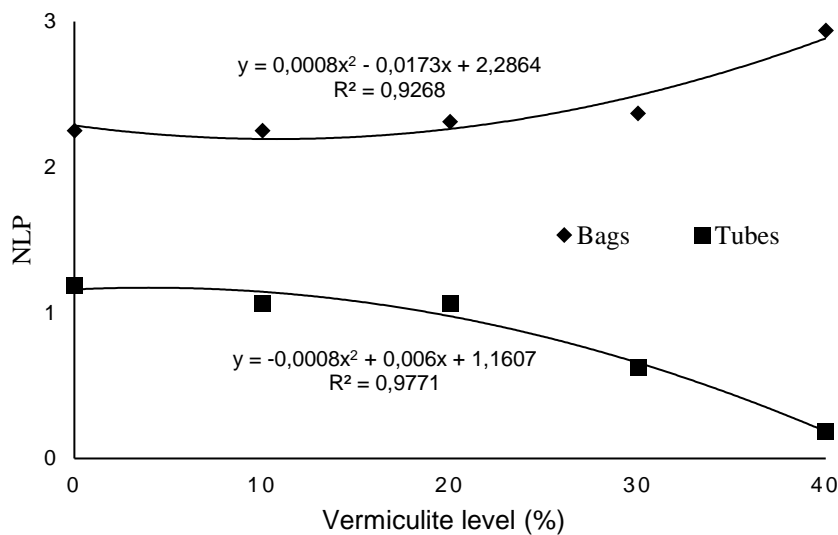


Figure 3. Number of leaf pairs (NLP) as a function of vermiculite levels for *Coffea arabica* L. seedlings, produced in polyethylene bags and tubes.

Table 3. Analysis of variance for Shoot Fresh Matter (SFM), Root Fresh Matter (RFM), Shoot Dry Matter (SDM) and Root Dry Matter (RDM) for *Coffea arabica* L. seedlings, produced in polyethylene bags and tubes.

FV	DF	Mean Squares			
		SFM (g)	SDM (g)	RFM (g)	RDM (g)
Container (C)	1	16.3792**	0.5759**	5.3766**	0.1004**
Vermiculite (V)	4	0.1352 ^{ns}	0.0054 ^{ns}	0.1125*	0.0026 ^{ns}
C x V	4	0.3017**	0.0168**	0.1320**	0.0042*
Block	3	0.0837	0.0007	0.0515	0.0009
Residue	27	0.0501	0.0030	0.02924	0.0012
CV (%)		19.25	19.95	33.08	24.67
General Mean		1.1635	0.2726	0.5169	0.1325

** , * e^{ns}: Significant at 1%, 5% and not significant, respectively, by the F test

The containers showed inverse trends in the linear regression analysis regarding the behavior of the variables analyzed in relation to the levels of vermiculite for SFM and SDM (Figures 4). The lower means of the shoot variables in the tube may be associated with low availability of nutrients in the substrate used in that container, where vermiculite, at higher levels, occupied part of the volume that would be destined for the substrate and thereby reduced the amount of nutrients to supply plant development. The regression analysis showed that, for root evaluation, both in RFM and RDM, only the seedlings produced in bags underwent a positive change as the level of vermiculite increased, while the seedlings

produced in tube did not show any difference in relation to this variable (Figure 5). In the case of the root system, an important factor that can favor its development is a good substrate porosity. Vermiculite acts as a conditioner: the higher its proportion in the substrate, the greater the macroporosity (Fermino & Kämpf, 2006; Caldeira et al., 2013). The possible change in the porosity of the standard substrate based on soil and manure, with the increase in vermiculite levels, proved to be adequate for root development in the bag. The tube did not suffer this tendency, as the commercial substrate possibly has high macroporosity and is not influenced by vermiculite.

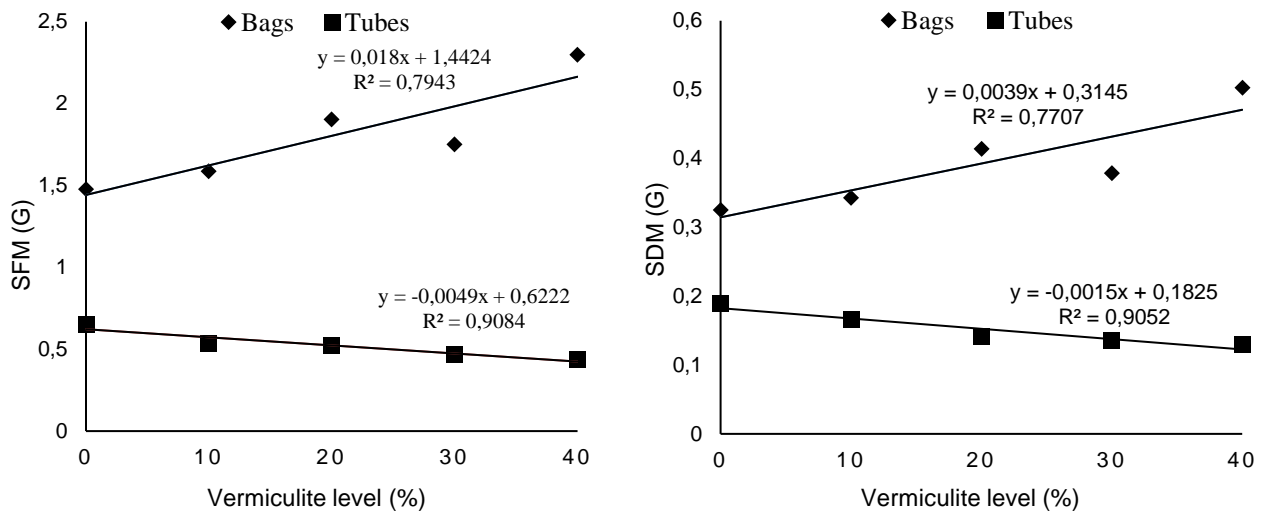


Figure 4. Shoot Fresh Matter (SFM) and Shoot Dry Matter (SDM) (g) as a function of vermiculite levels for *Coffea arabica* L. seedlings, produced in polyethylene bags and tubes.

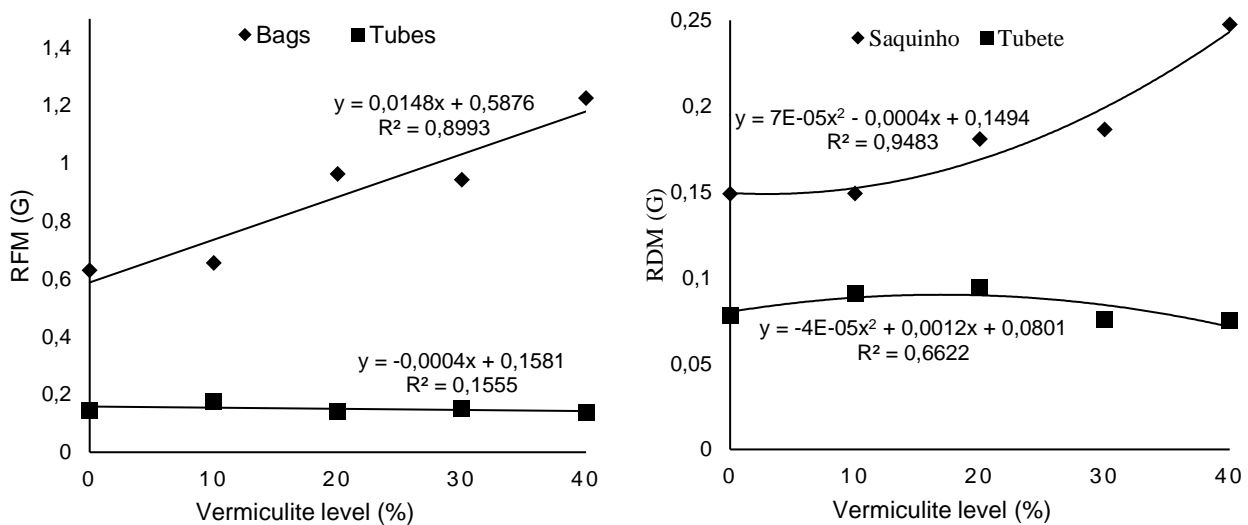


Figure 5. Root Fresh Matter (RFM) and Root Dry Matter (RDM) (g) as a function of vermiculite levels for *Coffea arabica* L. seedlings, produced in polyethylene bags and tubes.

As shown in the results, the seedlings produced in bags presented higher means for all parameters analyzed; the same was found by several authors (Alves et al., 2008; Vallone et al., 2009; Silva et al., 2010). This was probably due to the fact that the nutrients provided by commercial substrates are not sufficient to provide an adequate coffee development (Silva et al., 2010), thus requiring additional fertilization via substrate, covering applications or fertigation. In a study on the production of *Coffea canephora* seedlings, Silva et al. (2010) observed that the commercial substrate presented lower means for shoot height and stem diameter in relation to seedlings produced in bags with standard substrate. Silva et al. (2010) also performed leaf analysis on seedlings and those produced only with commercial substrate, when fertilizer was not provided, showed deficiency of macro-and micronutrients, mainly Mn, in relation to the bags with standard substrate, evidencing the need for a fertilization plan when using commercial substrates.

Conclusion

Seedlings produced in polyethylene bags showed greater vigor and initial development than seedlings produced in tubes.

Coffea arabica L. seedlings produced in polyethylene bags respond positively to the increase in vermiculite levels for the morphological characteristics analyzed.

Coffea arabica L. seedlings produced in tubes with a commercial substrate respond negatively to the increase in vermiculite levels for the morphological characteristics: Shoot Height (SH), Stem Diameter (SD), Root Length (RL), Number of Leaf Pairs (NLP), Shoot Fresh Matter (SFM), Root Fresh Matter (RFM).

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