

Short Research Article

Use of coffee *moinha*, commercial substrate, carbonized rice husk, coconut fiber and eggshell in the composition of alternative substrates for melon seedlings production

ABSTRACT

Research related to the use of agricultural residues as a way to partially or completely replace the commercial substrates has become fundamental, as it reduces the production costs of melon seedlings. The objective of this study was to evaluate the growth variables of melon seedlings grown on substrates composed of carbonized rice husk, coconut fiber, eggshell, increasing levels of coffee *moinha*, and decreasing commercial substrate substitution to the use of commercial substrate alone. The experiment was carried out in a completely randomized design, with five treatments and ten replicates, of which four treatments were used increasing proportions of *moinha* and decreasing amounts of commercial substrate (0/40, 10/30, 20/20, 30/10%) as well as fixed proportions of carbonized rice husk (40%), coconut fiber (15%), and egg shell (5%) and the fifth treatment used Bioplant® commercial substrate (control). At 19 days after sowing, the electrical conductivity of the substrates, dry masses of the root system and above-ground part, plant height, stem diameter, and number of leaves were evaluated. The alternative substrate containing proportions of 20% *moinha*, 20% commercial substrate, 40% carbonized rice husk, 15% coconut fiber, and 5% egg husk is recommended for the production of melon seedlings of the "yellow-type" cultivar seeded in 200-cell styrofoam trays.

Keywords: agricultural wastes, growth variables, *Cucumis melo*.

1. INTRODUCTION

The melon (*Cucumis melo* L.) belongs to the Cucurbitaceae family and is a much appreciated and very popular vegetable around the world, besides being one of the fresh fruits exported by Brazil [1].

Taking into account the melon planting in agricultural regions, the production of quality seedlings represents one of the most important phases in achieving high productivity. According to [2], poorly shaped or even weakened seedlings may compromise the entire crop performance, increasing its cycle length and generating production losses.

One of the factors that directly affect seedling quality is the type of substrate used. According to [3], the main function of the substrate is to support the seedling and provide adequate conditions for the growth and functioning of the root system as well as the nutrients necessary for plant growth. In addition, it should be free of invasive plant seeds, pests, and pathogenic fungi, thus avoiding the need for disinfestation. Reference [4] emphasizes that the choice of a substrate for seedling production should be based on two essential criteria: the acquisition cost and the availability of the material needed to produce the substrate.

In this sense, research related to the use of agricultural residues has been carried out as a way of replacing part or all of the commercial substrates, due to the reduction of seedling production costs. In addition, the use of waste generated in a given region is also a way of minimizing the environmental impacts caused by the incorrect disposal of such waste in the environment.

Among the residues generated in a large quantity in the Espírito Santo state which have the potential to be used in the composition of substrates, carbonized rice husks, coconut fibers, eggshells, and residues of the coffee drying process, also known as "*moinha*", stand out.

Due to some attributes such as the ease of drainage and water retention of carbonized rice husks [5], the good aeration and water retention of coconut fibers [6], the high amount of calcium in egg shells [7], and the fertilizer potential, especially the nitrogen in the *moinha* [8], such residues become interesting in the composition of an alternative substrate to the commercial one.

According to [8], *moinha* is composed of vegetal remains such as leaves, branches, remains of inflorescences, and poorly formed coffee beans, which, when dried together, are burned and released from the dryer machine. In quantifications made near the experiment, it was verified that for each bag of 60 kg of mature Conilon coffee processed, about 460 g of *moinha* were generated.

However, although the fertilizer potential [8], verified a high electrical conductivity in this residue, which is why they found that *moinha* concentrations greater than 10% in the substrate provided lower values of the variables analyzed in Conilon coffee plants. In this sense, different concentrations of *moinha* in the composition of the substrate and in different crops should be investigated, such as in melon seedlings, considering the hypothesis that this residue is an important component of the substrate but should be present in a suitable proportion, which requires experimentation.

Considering the above, it is believed that the partial substitution of commercial substrates by coffee *moinha* plus fixed proportions of carbonized rice husks, coconut fiber, and eggshell may be a sustainable alternative substrate that can be a substitute to the use of commercial substrate alone in the production of melon seedlings, since all components present characteristics favorable for the germination and development of seedlings, besides reducing costs, compared to commercial substrates. In this case, it is necessary to know the proportions of *moinha* and commercial substrate in the composition of the alternative substrate which will provide a better quality of seedlings for planting. The objective of this study was to evaluate the growth variables of melon seedlings grown on substrates composed of carbonized rice husk, coconut fiber, eggshell, increasing levels of coffee *moinha*, and decreasing amounts of commercial substrate to replace the use of commercial substrate alone.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The experiment was carried out at the seedling nursery of the Instituto Federal do Espírito Santo, Santa Teresa Campus, in Santa Teresa County, Espírito Santo state (18° 48' S, 40° 40' W; 127 m altitude), Brazil. The climate, according to the Köppen classification, is Cwa type (subtropical with dry winter), with an average annual temperature of 24.6 °C and annual average precipitation ranging from 700 to 1200 mm. The temperature and relative humidity of the air in the experimental period varied in the ranges of 19.9–38.2 °C and 47.5–69.5%, respectively. The nursery where the study was developed was covered with shading screen, which allowed a 50% reduction in solar radiation, as shown in the Figure 1.

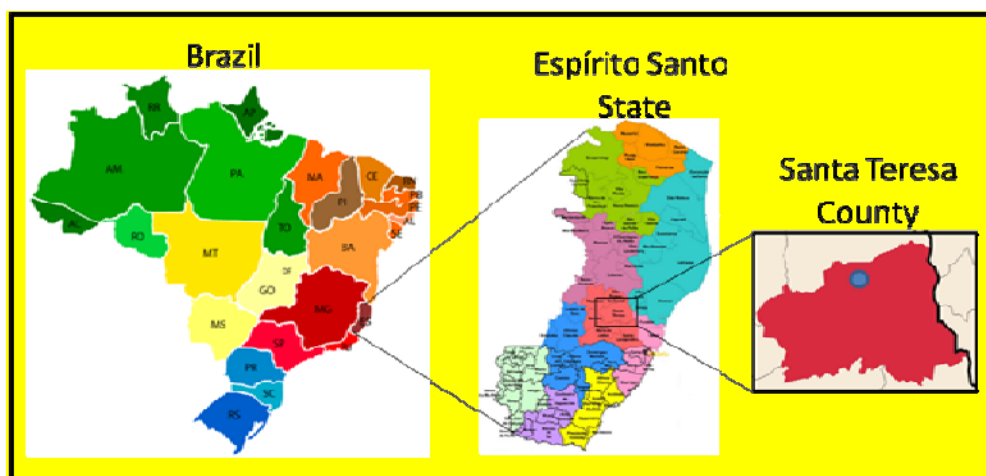


Figure 1. Localization of experimental area in Santa Teresa County, Espírito Santo State, Brazil [9].

The residues used in the alternative substrate for the production of melon seedlings were the residue from the drying of coffee beans, called "*moinha*", eggshell, coconut fiber, and carbonized rice husks. The eggshell was collected in restaurants in the region and dried by exposure to the sun for three days. Subsequently, it was crushed in a porcelain cup until a powder was obtained. The carbonized rice husks and coconut fiber were donated by Fibria, located in Aracruz city, ES, Brazil. The *moinha* was collected from Saudade Farm, located near the experimental area in Santa Teresa, ES, Brazil. Before use, the *moinha* was sieved in a stainless steel sieve with a 4-mm mesh.

The chemical and physicochemical characterization of the residues used in the composition of the substrates for the melon seedlings production was carried out at the Soil and Solid Wastes Laboratory of the Agricultural Engineering Department of the Universidade Federal de Viçosa. The physicochemical analysis consisted in the determination of the electrical conductivity (EC) in water (1:2.5) using a bench conductivity meter. The chemical analysis consisted of pH determination using a bench pH meter and the quantification of the concentrations of easily oxidizable organic carbon (OC_{eo}), total organic carbon (OC_T), total nitrogen (N_T), phosphorus (P), and potassium (K), following the methodology described by [10]. Table 1 presents the chemical and physicochemical attributes (EC) of coconut fiber, *moinha*, eggshell, and carbonized rice husks used in the experiment.

Table 1. Chemical and physical-chemical (EC) attributes of eggshell (ES), coconut fiber (CF), *moinha* (MO), and carbonized rice husk (CRH) used in the experiment.

Residues	pH	EC	OC_{eo}	OC_T	N_T	P	K	Ca
		$dS\ m^{-1}$	$dag\ kg^{-1}$					
ES	9.37	0.37	2.8	3.6	0.87	0.084	0.06	31.9
CF	7.15	0.09	57.1	74.1	0.66	0.053	0.14	–

	MO	5.60	6.49	45.3	58.9	3.7	0.14	0.71	–
	CRH	5.9	1.15	31.5	40.9	0.593	0.0816	0.0329	–
108	¹ pH – hydrogen potential; CE – electrical conductivity; OC _{eo} –easily oxidizable organic carbon; OC _t –								
109	total organic carbon; N _t – total nitrogen; P – phosphorous; K – potassium; Ca – calcium.								

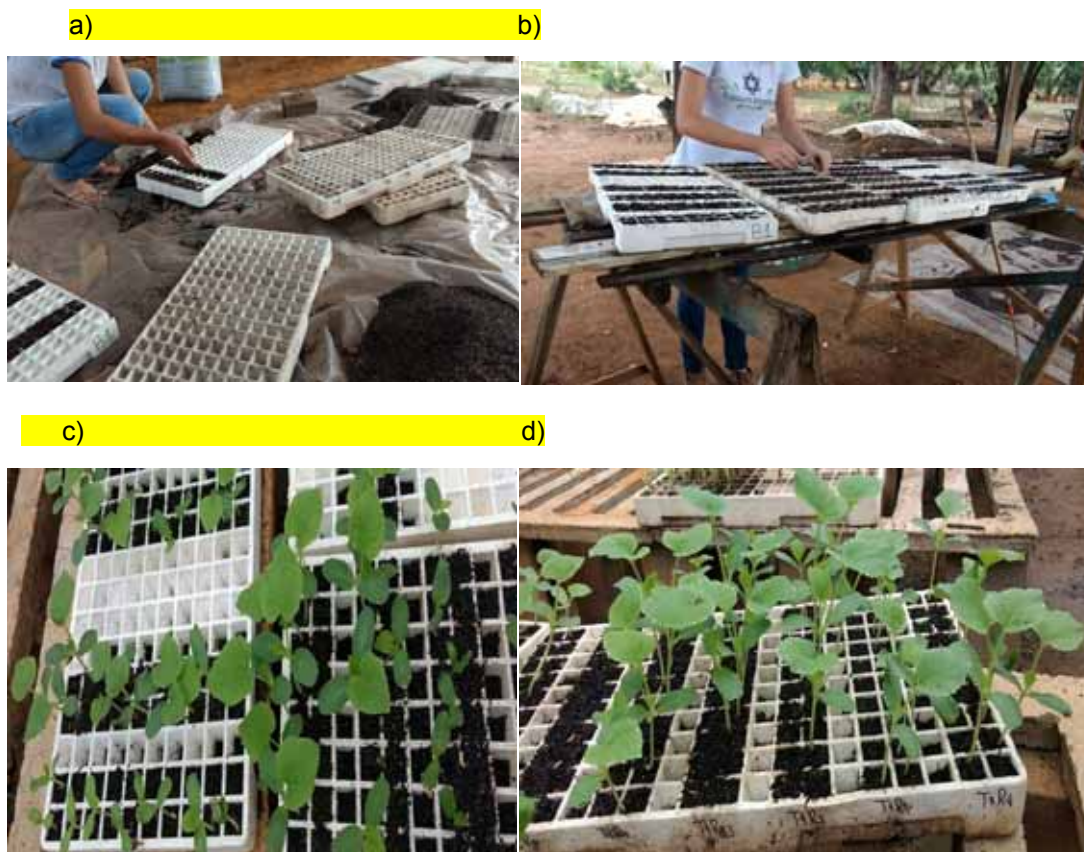
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111 Thus, the following treatments were evaluated: T1: Bioplant® commercial substrate (control);
112 T2: 0% *moinha* (MO) + 40% carbonized rice husk (CRH) + 15% coconut fiber (CF) + 5% egg
113 shell (ES) + 40% commercial substrate (CS); T3: 10% MO + 40% CRH + 15% CF + 5% ES
114 + 30% CS; T4: 20% MO + 40% CRH + 15% CF + 5% ES + 20% CS; and T5: 30% MO +
115 40% CRH + 15% CF + 5% ES + 10% CS.
116 The experimental design was completely randomized (DIC), with six treatments and ten
117 replicates. Each experimental unit consisted of 20 seedlings, considering 6 useful plants for
118 each experimental unit.
119 Table 2 shows the chemical attributes of the commercial substrate Bioplant®, obtained by
120 [11].
121

122 **Table 2. Chemical analysis of Bioplant® substrate.**
123

	N _T	P	K	Ca	OC _T	OM
pH ¹	-----dag kg ⁻¹ -----					
5.62	0.62	1.55	0.44	1.84	21.0	52.21

124 *¹pH in CaCl₂; OM – organic matter.
125

126 The melon seeds used were of the "yellow type" variety and were sown in styrofoam trays
127 with 200 cells each, placing one seed in each cell.
128 The seedling production system was used in suspended trays placed on masonry benches
129 which were hand irrigated twice a day, in the morning and in the afternoon. No fertilization
130 with fertilizers was carried out.
131 The evaluations took place at 19 days after sowing (DAS), when the seedlings were
132 considered suitable for implantation in the field. Evaluations consisted of measuring the
133 seedling height and stem diameter, counting the number of leaves, and quantifying the dry
134 masses of the above-ground part and root of the plants. To obtain the height of the above-
135 ground part, a millimeter ruler was used, measuring from the base of the stem to the apical
136 bud from which the last leaf emerged. The diameter of the stem was obtained by means of a
137 precision digital caliper. To obtain the dry masses of the above-ground part and root, the
138 cuttings were done close to the substrate, washing the roots carefully in running water on a
139 sieve. Then, the above-ground part and the roots were packed in paper bags and placed in
140 an oven with forced air circulation at 65°C for 72 hours. Subsequently, the materials were
141 weighed on an electronic precision scale with an accuracy of 0.01 g. In addition to the
142 biometric and gravimetric analyses, the electrical conductivity of the substrates was
143 determined using a conductivity meter, following the methodology proposed by [10].
144 In the Figure 2, it is shown the experiment implantation ("a" and "b") as well as the seedlings
145 evaluation at the 19 DAS ("c" and "d").
146



147 **Figure 2. Implantation of the experiment (“a” and “b”), and seedlings evaluation (“c”**
 148 **and “d”).**

149 All the evaluated variables were submitted to normality (Lilliefors), additivity (Tukey), and
 150 homoscedasticity (Bartlett) tests, that was needed for the validation of their variance
 151 analyzes. The variable number of leaves (NF) did not meet the assumptions, so it was
 152 decided to evaluate it through the nonparametric test of Kruskal Wallis, considering the
 153 evaluation of the effects of the treatments by stations or ordering scales. Due to the
 154 qualitative difference between the commercial substrate treatment (T1) and the others (T2 to
 155 T6), the Dunnett test was performed to compare each treatment with T1 (control). An “ α ”
 156 value of 0.05 was used for all procedures. All statistical analyses were performed using
 157 SAEG 9.1 software (2009).

158 159 3. RESULTS AND DISCUSSION

160
 161 Table 3 shows the averages for each of the analysed variables, as well as the Dunnett test
 162 results, comparing the mean values for the treatments with increasing levels of *moinha* and
 163 fixed proportions of carbonized rice husk, coconut fiber, and eggshell against the values for
 164 the control treatment (commercial substrate) at 19 DAS.

165
 166
 167

Table 3. Estimated averages for plant height (PH), stem diameter (SD), above-ground dry matter mass (AGDMM), root dry matter mass (RDMM), and electrical conductivity (EC) of the substrates in treatments using commercial substrate only (control) and in treatments containing increasing levels of *moinha* and decreasing levels of commercial substrate containing fixed proportions of carbonized rice husk, coconut fiber, and eggshell at 19 DAS.

	Commercial substrate	Increasing levels of <i>moinha</i> : decreasing levels of commercial substrate (%)				α Error
		0:40	10:30	20:20	30:10	
PH (cm)	4.37	5.36	5.72*	7.02*	4.95	0.0001
SD (mm)	2.01	2.50*	2.53*	2.99*	2.27	0.0001
AGDMM (g)	0.47	0.58	0.65	0.73*	0.39	0.0023
RDMM (g)	0.22	0.28	0.22	0.27	0.17	0.0045
EC ($\mu\text{S cm}^{-1}$)	60.0	83.33	113.33*	110.0	125.0*	0.0163

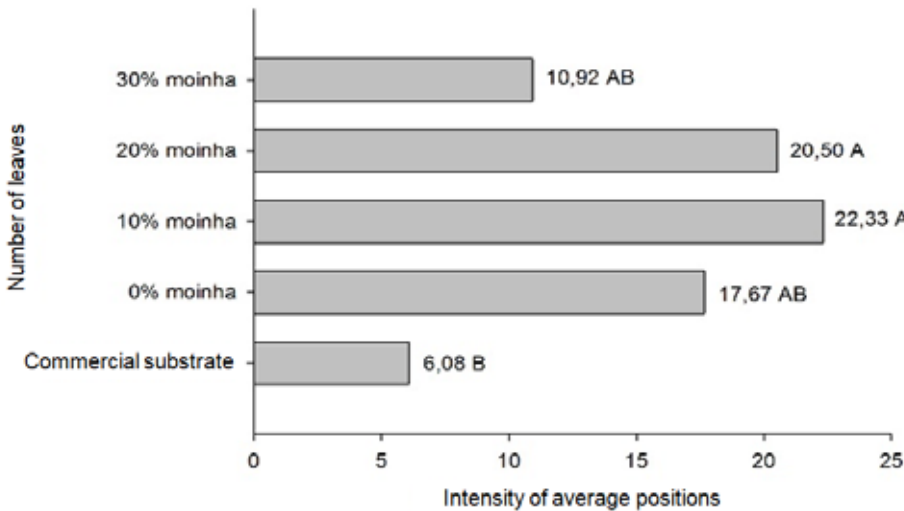
Averages, in rows followed by an asterisk (), differ from the "control" at 5% probability level.

According to Table 3, it can be observed that for the plant height (PH), the treatments containing 10 and 20% *moinha* presented statistically higher averages than the control, evidencing that the increment of the *moinha* concentration up to the proportion of 20% in the substrate composition promoted increasing values of PH. This fact may be associated with the higher amount of nutrients in this residue, notably nitrogen (Table 1). According to [12], nitrogen favors leaf expansion and provides greater plant growth when applied in adequate doses. The effect of Nitrogen up to the optimum level increases cytokinin production, which subsequently affects the cell wall elasticity [13], the number of meristematic cells and cell growth [14].

The other treatments with alternative substrates (0:40 and 30:10) do not give different results from the control at 5% probability level, indicating that for this variable it is possible to use proportions of 30:10% (*moinha*: commercial substrate) without damaging the quality of melon seedlings. The highest value obtained for plant height (7.02 cm) when using the 20:20 ratio was above the value reached by [15] when evaluating the growth and development of the AF682 variety of melon seedlings grown on different substrates (soil; sterilized soil; sugarcane bagasse; soil + sugarcane bagasse; and sugarcane bagasse + urea), that obtained AP values ranging from 4.99 to 5.82 cm at 14 DAS in their study. However, the PH values obtained in this study were lower than those obtained by [16], which evaluated the emergence and development of yellow melon seedlings on sheep-manure substrates and obtained values between 7.63 and 12.06 cm. It should be considered that the evaluation

195 carried out by [16] was performed at 27 DAS in expanded polystyrene trays of 128 cells,
 196 whereas in this experiment the evaluation was done at 19 DAS and in trays of 200 cells.
 197 For the SD variable (Table 3), only the substrate with a ratio of 30:10% (*moinha*: commercial
 198 substrate) does not give different results from the control at the 5% probability level,
 199 indicating that for this variable, as verified for PH, it is possible to use up to 30% *moinha* in
 200 the substrate composition without causing damage to the melon seedlings. The other
 201 treatments with alternative substrates (*moinha*: commercial substrate ratios of 0:40, 10:30,
 202 and 20:20) differ from the control, presenting averages statistically superior to those
 203 obtained with use of only the commercial substrate Bioplant®. The highest stem diameter
 204 value obtained in this work (2.99 mm), using the 20:20 ratio, was higher than that obtained
 205 by [16], which, on evaluating the emergence and development of yellow melon seedlings on
 206 substrates composed of sheep manure, obtained a maximum stem diameter of 2.7 mm at 27
 207 DAS in trays containing 128 cells. [17], evaluating the quality of pepper seedlings produced
 208 in alternative substrates, did not find a value greater than 2.12 mm for stem diameter, using
 209 earthworm humus as an alternative substrate at 33 DAS.
 210 With regard to the AGDMM (Table 3), the content of 20% *moinha* in the substrate
 211 composition led to a statistically higher mean of this variable than the control. As the other
 212 treatments do not lead to different results from the control at the 5% probability level, it is
 213 possible to use the proportion of 30% *moinha* in the composition of the substrates without
 214 causing harm to the melon seedlings. The statistically superior value of AGDMM in this work
 215 (0.73 g) when compared to the control treatment (0.47g) may be related to the greater and
 216 adequate availability of nutrients in the substrate and assimilation by the seedling. These
 217 results corroborate those found by [16], where agricultural residues provided indicators of
 218 vegetable seedling development similar or superior to those found with commercial products.
 219 The results obtained in this work using the alternative substrates were superior to those
 220 obtained by [15], which at 14 DAS obtained a maximum value of AGDMM in cultivar melon
 221 AF682 of 0.09 g using Plantmax® substrate. In a similar way, the results of this work were
 222 also superior to those obtained by [16], which, on evaluating the emergence and
 223 development of yellow melon seedlings on substrates with sheep manure, obtained values
 224 between 0.104 and 0.168 g at 27 DAS.
 225 According to [18], the formation of larger roots allows the seedlings to better exploit the
 226 volume of substrate available, allowing a greater absorption of water and nutrients due to the
 227 increase of its porosity. Therefore, it is possible to use physical conditioners (rice husk,
 228 sugar cane bagasse, sand, etc.) in the mixture of components to form an alternative
 229 substrate, avoiding the formation of possible layers that could impede the growth of the root
 230 system. According to Table 3, it was found that the control treatment (commercial substrate)
 231 did not differ from any of the treatments containing increasing proportions of *moinha* in the
 232 composition of the alternative substrate.
 233 The results for RDMM obtained in this work (0.17 to 0.28 g) using the alternative substrates
 234 were well beyond those obtained by [19], which, when analyzing the use of organic sources
 235 as substrate in the production of melon seedlings, did not obtain values higher than 0.063 g
 236 of RDMM per plant using goat manure + sand, evaluated at 23 DAS. In a similar way, they
 237 were also higher than those obtained by [15], which reached a maximum RDMM value of
 238 0.019 g in AF682 variety melon at 14 DAS, using Plantmax® substrate.
 239 With regard to the EC variable of the substrate, the substrate compositions with *moinha*
 240 contents of 10 and 30% led to statistically higher values than the control. This result was
 241 already expected because the *moinha* is residue with a high EC (Table 1). Nevertheless,
 242 when mixed with other residues, it did not reach values that could cause damage to the
 243 development of seedlings. [20] classifies the EC into levels: very low (0 to 0.25 dS m⁻¹), low
 244 (0.26 to 0.75 dS m⁻¹), normal (0.76 to 1.25 dS m⁻¹), high (1.26 to 1.75 dS m⁻¹), very high
 245 (1.76 to 2.25 dS m⁻¹), and extreme (above 2.25 dS m⁻¹). In this case, the values reached in
 246 this study (0.113 and 0.1125 dS m⁻¹) are in the range considered very low.

247 Figure 1 shows the intensity of the average positions of the variable NL for the treatments
248 containing only the commercial substrate (control) and those containing different proportions
249 of *moinha* and commercial substrate.



250
251 **Figure 3. Comparison of the average positions of the number of leaves (NL) of the**
252 **melon seedlings as a function of the different *moinha* levels added to the substrates.**

253 Analyzing Figure 1, it can be verified that the treatments containing proportions of 10:30 and
254 20:20 (*moinha*: commercial substrate) were statistically superior to the treatment using only
255 the commercial substrate. This can be attributed to the greater quantity of nutrients available
256 when compared with the use of commercial substrate alone. Even the treatment with the
257 proportions of 30:10 (*moinha*: commercial substrate) containing the highest amount of
258 nutrients showed no statistical difference ($P < 0.05$) from the commercial substrate. The
259 effect of the possible presence of soluble tannins in the treatment with the largest amount of
260 *moinha* may have outweighed the effect of the availability of nutrients in this residue. In
261 larger quantities, soluble tannins are phytotoxic and inhibit root growth, affecting the
262 development of the plant as a whole. As a result of the results obtained, it was verified that
263 the alternative substrates containing *moinha* and commercial substrate proportions of up to
264 30:10%, combined with carbonized rice husk (40%), coconut fiber (15%), and egg shell
265 (5%), can be used instead of the commercial substrate alone without any damage to the
266 quality of melon seedlings. However, the 20:20 ratio of the alternative substrate proved to be
267 the most efficient because it led to values higher than those obtained with commercial
268 substrate alone for most of the growth variables analyzed.

269
270 **4. CONCLUSION**

271
272 Use of the alternative substrate containing proportions of 20% *moinha*, 20% commercial
273 substrate, 40% carbonized rice husk, 15% coconut fiber, and 5% eggshell is recommended
274 for the production of melon seedlings of the "yellow type" variety seeded in 200-cell
275 styrofoam trays.

276
277 **COMPETING INTERESTS**

278
279 The authors state that there are no competing interests.
280

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