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Production of *Pouteria gardneriana* (A. DC.) Radlk. seedlings on different substrates

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The aim of this study was to evaluate growth characteristics, nutrition and seedling quality of guapeva produced on different substrates. The substrates used here included MecPlant®+rice husk (RH), fine vermiculite+subsoil+decomposed corn silage (FV+SB+DCS), and subsoil coarse sand composted cattle manure (SB+CS+CCM) at the ratios 7:3, 3:1:6, and 2:2:1, respectively, and FV+SB+RH at ratios 2:2:1 and 1:1:1; proportions are expressed on a volume basis. The following evaluations were performed 130 days after sowing: percentage of emerged seedlings; emergence speed index; stem length (SL), root collar diameter (RCD), number of leaves (NL), leaf area (LA), dry weight of the roots, stems and leaves and the whole plant; macro- and micronutrients in the leaves; ratios of SL and RCD (SL/RCD), SL and NL (SL/NL). A higher percentage of plants emerged and with greater vigor on the substrate MP+RH compared to SB+CS+CCM. The NL, LA, leaf dry weight and total plant dry weight were greater on the substrates that had DCS or CCM in their composition, but the other biometric characteristics were not affected by the different substrates. Substrates that had CCM or DCS also had the highest leaf concentrations of P, Ca, Mg, S and B. The foliar concentration of Mn was highest on the MP+RH substrate. The SL/RCD ratio was higher in the seedlings grown in substrates that included DCS and CCM in their composition, but these components yielded a lower R/S ratio. Overall, substrates with CCM and DCS favored guapeva seedling growth.

Key words: *Pouteria gardneriana* (A. DC.) Radlk., quality of seedlings, plant nutrition.

INTRODUCTION

The fruits of Cerrado (Brazilian savannah) fruit tree species have unique flavors and are thus characterized as exotic fruits. In addition to being used as food, they also have potential pharmacological and nutraceutical properties. In a review of the chemical composition and biological activity of fruits in the genus *Pouteria*, Silva et al. (2009) notes that several species of this genus produce bio-molecules with biological activity, including anti-inflammatory, antibacterial, antifungal, and antioxidant activities. The authors also report that the real

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potential of the molecules produced by *Pouteria* species for use as pharmaceuticals is still unclear. A protein from seeds of the genus *Pouteria* has been reported to have cytotoxic activity against mammalian tumor cells (Boleti et al., 2008).

Adequate use of the benefits provided by the species of the genus *Pouteria* is possible through the propagation of these species. High-quality, hardy and healthy seedlings are needed for the successful propagation of woody species. These characteristics ultimately contribute to the survival of plants after they are transplanted in the field, thus resulting in successful reforestation and orchard establishment. Quality indicators for seedlings include a balance between growth and development, physiological quality and hardiness, which are defined using ratios and indices that consider the balance between the weight of the root system and plant shoot and the degree of etiolation. Substrate quality is one of the main factors that influence seedling quality (Ferraz et al., 2005; Dornelles et al., 2014).

For a substrate to be considered adequate, it should have the following characteristics: accommodation in the container so that the substrate forms the appropriate size and number of pores; slow decomposition; high cation-exchange capacity; free of phytopathogens and other plant seeds; available for purchase at reasonable prices (Dantas et al., 2009). These characteristics can be achieved by mixing two or more components that have different characteristics and that when mixed together provide a substrate with characteristics that are suitable for growing seedlings (Araújo Neto et al., 2009).

There are few studies that have examined the production of seedlings of the species *Pouteria gardneriana* (A. DC.) Radlk. Thus, the aim of the present study was to evaluate the growth characteristics, nutrition and quality of *P. gardneriana* (A. DC.) Radlk. seedlings grown on different substrates.

MATERIALS AND METHODS

The *P. gardneriana* (A. DC.) Radlk. fruits originated from the Fazenda Gameleira (Gameleira Farm) located in the municipality of Montes Claros de Goiás, state of Goiás (GO), Brazil (19°53'S, 44°25'W). The fruit was harvested from plants in full production (Figure 1). Seeds were obtained by manually pulping the fruit to remove the mucilage surrounding the seeds, which were then placed in a 1 M sodium hydroxide solution for approximately five minutes with stirring. The seeds were then manually rubbed under running water to remove residual mucilage and NaOH.

The experiment was conducted in a greenhouse at the Federal Institute Goiano (Instituto Federal Goiano) (17° 48'S, 50° 54'W). Temperature and relative humidity data were recorded using a DataLogger (NOVUS, Porto Alegre, Brazil), and the average daily temperature and relative humidity were 25°C and 77%, respectively. The sprinkler irrigation was split into two applications, in a daily volume of 12 mm.

The following components were used to formulate the substrates: fine vermiculite (FV), MecPlant® (MP), subsoil (SB), rice husk (RH), decomposed corn silage (DCS), coarse sand (CS), and composted cattle manure (CCM). Five substrates were formulated using ratios based on volume as follows: MP+RH (7:3), FV+SB+DCS (3:1:6), SB+CS+CCM (2:2:1) and FV+RH+SB at ratios of 2:2:1 and 1:1:1. After preparing the substrates, samples were collected for physical and chemical analyses. The chemical analyses of the substrates were performed according to Tedesco et al. (1995) recommendations, and the results are shown in Table 1. The physical analyses of dry-bulk density, available water and total porosity were performed according to Fermino et al. (2010). A single seed was planted per container, which had a 288 cm^3 capacity.

The percentage of emerged seedlings (PES) was evaluated at two-day intervals during the period comprising the emergence of the first and last seedling, and the emergence speed index (ESI) was determined (Maguire, 1962).

The evaluations performed upon collection of the plants at 130 days after sowing included the stem length (SL), root collar diameter (RCD), the number of leaves (NL), leaf area (LA) and the dry weight of the roots, stems and leaves of plants after they were separated. The plants were dried at 65°C in a forced air oven until they achieved a constant weight. To evaluate the quality of the seedlings, the following parameters were calculated: the SL and RCD ratio (SL/RCD), the ratio between the dry weight of the roots and shoots of the plants (R/S) and the Dickson quality index (DQI) (Saidelles et al., 2009). For the nutritional evaluation of the leaves, the dry material was ground in a Wiley mill and quantified based on the methods described by Tedesco et al. (1995).

The experimental design consisted of a randomized block design with five replicates. PES and ESI evaluations was done in 20 experimental container. For the growth characteristics, weight accumulation and seedling quality, five experimental units per replicate were randomly distributed for the evaluation. To quantify the nutrients in leaf tissue, leaves from each replicate were pooled. For the physical analyses of the substrates, representative samples were used for each substrate immediately after preparation, and each sample comprised five sub-samples. Analysis of variance (ANOVA) was used to analyze the data, and Tukey's test was used to discriminate the least significant difference between the means ($p < 0.05$). The ANOVA, means test and Pearson's correlation were performed using the statistical software SAEG 9.1.

RESULTS AND DISCUSSION

The substrates differed in their physical properties; the total porosity (TP) was higher in the substrates MP+RH and FV+SB+DCS than in the other substrates (Table 2). The TP values of the substrates tested were lower than the optimal 85% according to Lemaire (1995), which suggested that the optimal TP should be between 0.75 and 0.90 $m^3 m^{-3}$. The substrates FV+SB+DCS had the highest available water (AW) values, followed by FV+SB+RH (1:1:1) and SB+CS+CCM, which were not significantly different from each other, whereas the substrates MP+RH and FV+SB+RH had the lowest values. The only substrate that had an AW within the optimal range of 0.24 to 0.40 $m^3 m^{-3}$ according to Liz and Carrijo (2008) was FV+SB+DCS, whereas the other substrates had lower values, which may compromise their water availability. TP values are similar to those reported by Dornelles et al. (2014) already AW of this study is intermediate to found by Dornelles et al. (2014), except the FV + SB + DCS which was superior.

The dry-bulk density (DBD) of all the substrates was different, displaying the following order: SB+CS+CCM >

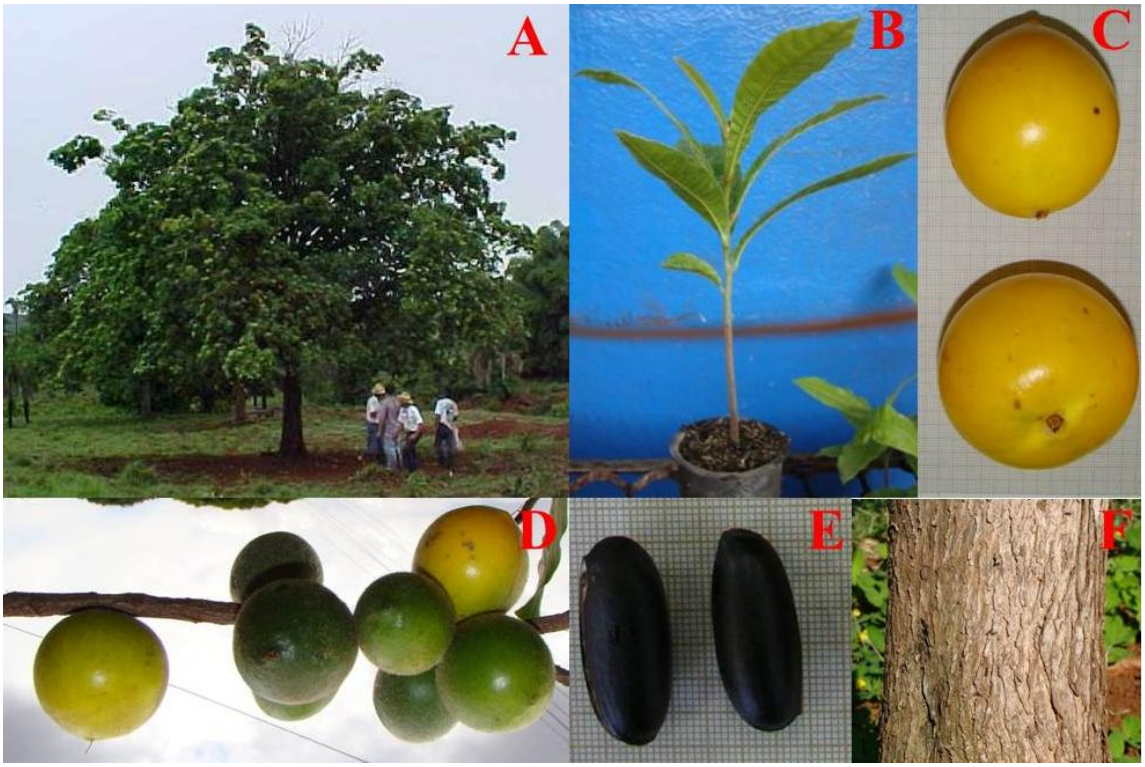

Figure 1. Parental plant (A) and seedlings (B) of *Pouteria gardneriana* (A. DC.) Radlk., mature fruit (C), branch with fruits (D), seeds (E) and stem (F).

Table 1. Chemical and macro- and micronutrient analyses of the substrates tested.

Substrate	pH	MO	Ca	Mg	P	K	Zn	Fe	Mn	Cu	B
		dag kg^{-1}	cmolc/dm^3		mg/dm^3						
MP^y+RH^x (7:3)	4.10	61.95	4.70	2.42	195.3	487.0	9.35	163.3	57.3	6.2	1.23
FV^w+SB^v+RH (2:2:1)	6.72	3.65	6.00	4.50	39.2	171.0	2.50	79.2	17.4	1.47	0.13
FV+SB+RH (1:1:1)	6.41	4.56	9.00	3.11	7.7	175.0	2.64	71.5	19.6	1.82	0.19
FV+SB+DCS^u (3:1:6)	7.05	13.17	4.11	4.39	35.9	347.0	10.93	87.1	39.1	1.52	0.48
SB+CS^t+CCM^s (2:2:1)	6.80	5.96	4.50	4.00	183.41	542.88	23.82	43.15	56.79	3.16	0.56

^{y}MecPlant®; ^{x}Rice husk; ^{w}Fine vermiculite; ^{v}Subsoil; ^{u}Decomposed corn silage; ^{t}Coarse sand; ^{s}Composted cattle manure.

Table 2. Total porosity (TP), available water (AW), dry-bulk density (DBD) of the substrates studied on *P. gardneriana* seedlings.

Substrate	TP (m^3 m^{-3})	AW (m^3 m^{-3})	DBD (kg m^{-3})
MP^y+RH^x (7:3)	0.722 ^{a}	0.109 ^{c}	222.1 ^{e}
FV^w+SB^v+RH (2:2:1)	0.567 ^{b}	0.093 ^{c}	477.7 ^{c}
FV+SB+RH (1:1:1)	0.516 ^{b}	0.153 ^{b}	717.8 ^{b}
FV+SB+DCS^u (3:1:6)	0.730 ^{a}	0.265 ^{a}	349.6 ^{d}
SB+CS^t+CCM^s (2:2:1)	0.474 ^{b}	0.171 ^{b}	1284.1 ^{a}
LSD^r	0.118	0.042	36.4

zMeans followed by the same letter are not significantly different from each other based on Tukey's test ($p < 0.05$); ^{y}MecPlant®; ^{x}Rice husks; ^{w}Fine vermiculite; ^{v}Subsoil; ^{u}Decomposed corn silage; ^{t}Coarse sand; ^{s}Composted cattle manure; ^{r}Least significant difference.

Table 3. Percentage of emerged seedlings (PES) and emergence speed index (ESI) for *Pouteria gardneriana* seedlings grown on different substrates.

Substrate	PES (%)	ESI(-)
MP[y]+RH[x] (7:3)	87 [az]	0.53 [a]
FV[w]+SB[v]+RH (2:2:1)	82 [ab]	0.42 [ab]
FV+SB+RH (1:1:1)	83 [ab]	0.44 [ab]
FV+SB+DCS[u] (3:1:6)	76 [ab]	0.45 [ab]
SB+CS[t]+CCM[s] (2:2:1)	63 [b]	0.33 [b]
LSD[r]	21.3	0.150

[z]Means followed by the same letter are not significantly different from each other based on Tukey's test ($p < 0.05$); [y]MecPlant®; [x]Rice husks; [w]Fine vermiculite; [v]Subsoil; [u]Decomposed corn silage; [t]Coarse sand; [s]Composted cattle manure; [r]Least significant difference.

FV+SB+RH (1:1:1) > FV+SB+RH (2:2:1) > FV+SB+DCS > MP+RH. Kämpf (2000) classifies the optimal density in ranges according to containers in trays, containers with a height of 15 cm, containers with a height of 20 to 30 cm and containers with a height greater than 30 cm, for which the optimal densities are 0.1 to 0.3, 0.25 to 0.4, 0.3 to 0.5 and 0.5 to 0.8 kg m^{-3}, respectively. The densities of the substrates tested here were adequate in all the Kämpf (2000) classifications except for containers in a tray, where the substrate SB+CS+CCM displayed a density that was outside the suitable range for substrates, having a density more characteristic of soil.

The percentage of emerged seedlings (PES) was higher for the MP+RH substrate than for the substrate SB+CS+CCM, with values of 87 and 63%, respectively. A similar difference was observed for plant vigor (Table 3). The higher PES and ESI values observed for the substrate MP+RH compared to SB+CS+CCM may be due to the different densities of the substrates because these substrates were on the extreme end for DBD; the first substrate had a lower density. PES and ESI are negatively correlated with DBD (-0.54 and -0.64, respectively), and the ESI was positively correlated (0.50) with the total porosity of the substrate (TP), whereas the PES did not show a correlation. In addition, both PES and ESI were not correlated with available water. According to Nogueira et al. (2003) and Dornelles et al. (2014), to promote germination and emergence of a seedling, the substrate should exhibit a porosity that provides aeration and moisture for the seed, thereby providing water and oxygen for metabolism, given that a seedling does not require nutrients to germinate or emerge.

The leaf biometric characteristics, such as the number of leaves, leaf area and leaf dry weight, in addition to the total dry weight of the plants were affected by the substrates (Table 4). The other biometric characteristics were not affected by the different substrates. The highest number of leaves was observed on plants grown on the substrate FV+SB+DCS compared to MP+RH and FV+SB+RH at the ratios of 2:2:1 and 1:1:1-in other words, all those that have rice husks as part of their composition. The plants grown on the substrates FV+SB+DCS and SB+CS+CCM had a greater leaf area and leaf dry weight compared to the plants grown on the other substrates. The accumulation of total dry weight of the seedlings was higher on the substrate FV+SB+DCS than on FV+SB+RH (1:1:1).

Overall, substrates with CCM and DCS favored the leaf characteristics of *P. gardneriana* (A. DC.) Radlk. plants compared to the other substrates that did not have these components. Decomposed organic matter and composted cattle manure are commonly used as substrate components for seedling production because these components improve the physical and chemical quality of the substrates. Cattle manure has been used in various studies on seedling production due to these benefits (Abreu et al., 2005; Costa et al., 2005; Cunha et al., 2006).

When CCM or DCS were included in the substrates, they provided higher foliar concentrations of the nutrients P, Ca, Mg, S and B compared to other substrates that did not include these components. In addition, the concentrations of Mg and S were higher when CCM was included than when DCS was included (Table 5). The substrate FV+SB+RH at a ratio of 2:2:1 provided higher leaf concentrations of K than the same substrate components at the 1:1:1 ratio. For the micronutrient Mn, the highest foliar concentrations were observed in the substrate MP+RH. The other nutrients measured (N, Fe, Cu, Zn and Na) were not affected by the composition of the substrates.

The use of composted cattle manure is widely recognized and recommended as a component in substrates for seedling production due to its ability to provide nutrients for the plants (Marinari et al., 2000; Araújo and Sobrinho, 2011; Naddaf et al., 2011; Silva et al., 2011), but harmful effects of its use have also been reported (Dias et al., 2009). According to Lekasi et al. (2003), one of the limitations of using manure as a

Table 4. Stem length (SL), root collar diameter (RCD), number of leaves (NL), leaf area (LA), dry weight of stems (SDW), leaves (LDW), root (RDW), total (TDW) of *Pouteria gardneriana* seedlings grown on different substrates.

Substrate	SL	RCD	NL	LA	SDW	LDW	RDW	TDW
	(cm)	(mm)	-	(cm^2)			(g)	
MP[y]+RH[x] (7:3)	20.9[ns]	3.78[ns]	6.7[bc]	224.4[b]	0.63[ns]	1.41[b]	1.14[ns]	3.18 [ab]
FV[w]+SB[v]+RH (2:2:1)	20.4	3.69	6.2[c]	193.2[b]	0.58	1.18[b]	1.20	2.96 [ab]
FV+SB+RH (1:1:1)	20.3	3.59	6.4[c]	193.5[b]	0.55	1.15[b]	1.14	2.84 [b]
FV+SB+DCS[u] (3:1:6)	22.8	3.61	8.2[a]	360.0[a]	0.73	2.04[a]	1.12	3.89 [a]
SB+CS[t]+CCM[s] (2:2:1)	23.0	3.63	7.8[ab]	375.7[a]	0.70	1.98[a]	1.03	3.71 [ab]
LSD[r]	3.03	0.450	1.20	80.30	0.206	0.494	0.350	0.941

[z]Means followed by the same letter are not significantly different from each other based on Tukey's test ($p < 0.05$); [y]MecPlant®; [x]Rice husks; [w]Fine vermiculite; [v]Subsoil; [u]Decomposed corn silage; [t]Coarse sand; [s]Composted cattle manure; [r]Least significant difference. [Ns]No significant differences between means.

Table 5. Macro- and micronutrients in leaf tissue of *Pouteria gardneriana* seedlings grown on different substrates.

Substrate	N	P	K	Ca	Mg	S	B	Fe	Cu	Mn	Zn	Na
	mg g^{-1}						mg kg^{-1}					
MP[y]+RH[x] (7:3)	1.1[ns]	0.12[bz]	0.77[ab]	0.8[b]	0.24[c]	0.05[c]	27[b]	230[ns]	6.6[ns]	232[a]	1.2[ns]	88[ns]
FV[w]+SB[v]+RH (2:2:1)	1.1	0.09[b]	0.91[a]	0.5[c]	0.26[c]	0.08[bc]	16[c]	189	5.6	31[b]	1.8	88
FV+SB+RH (1:1:1)	1.2	0.10[b]	0.64[b]	0.5[c]	0.21[c]	0.05[c]	12[d]	172	7.6	36[b]	1.4	84
FV+SB+DCS[u] (3:1:6)	1.2	0.20[a]	0.83[ab]	1.3[a]	0.37[b]	0.12[b]	33[a]	186	8.6	38[b]	1.8	82
SB+CS[t]+CCM[s] (2:2:1)	1.2	0.18[a]	0.78[ab]	1.2[a]	0.47[a]	0.19[a]	32[a]	202	7.8	22[b]	3.0	80
LSD[r]	0.12	0.058	0.27	0.19	0.09	0.053	3.4	60	4.8	28	2.2	18

[z]Means followed by the same letter are not significantly different from each other based on Tukey's test ($p < 0.05$); [y]MecPlant®; [x]Rice husks; [w]Fine vermiculite; [v]Subsoil; [u]Decomposed corn silage; [t]Coarse sand; [s]Composted cattle manure; [s]Least significant difference. [ns]No significant differences between means.

substrate component is that its quality and chemical composition can vary dramatically based on the location and region where it is obtained, on the quality of the pasture that the cattle are offered and on the management of the animals.

The concentrations of the nutrients in the leaves, especially the macronutrients, are positively correlated with the biometric characteristics of the plant; in other words, an increase in the levels of a particular biometric characteristic is related to an increase in one or more of these nutrients (Table 6). The levels of Ca and B in the leaves showed the greatest correlation with the biometric characteristics of the plant including the SL, NL, LDW, LA, SDW and TDW. The levels of Mg also correlated with all of these same characteristics except SDW. N was the one nutrient that correlated the least with the biometric characteristics and showed a significant correlation for only NL. The levels of P were only slightly better than those of N, showing a significant correlation with NL, LDW and LA, or, in other words, only with the leaf characteristics. S was correlated with SL, NL, LDW and LA. The other elements did not show any correlations.

The positive correlations between the nutrients Ca, B, Mg, S, P and N and the biometric characteristics indicate that when the concentrations of these nutrients increased in the leaf tissue, the biometric measurements also showed a similar increase. These data indicate that the concentrations of these elements may be too low for plants to achieve their maximum growth potential, as defined by Liebig's law of the minimum. However, because there are few studies of *P. gardneriana* Radlk. species, it is not possible to compare leaf concentrations of Ca, B, Mg, S, P and N and determine whether these levels are actually lower than the optimal concentrations for these species.

The ratio between stem length and root collar diameter (SL/RCD) was higher in the seedlings grown on substrates that contained DCS and CCM compared to the substrates MP+RH and FV+SB+RH (2:2:1) (Table 7). Higher SL/RCD values indicate possible etiolation of the plants, yielding plants with more fragile stems that are more susceptible to breakage. However, the average distance between internodes (SL/NL) of seedlings of *P. gardneriana* (A. DC.) Radlk. was not significantly different for the plants grown on different substrates, indicating that the observed differences in the SL/RCD values are not the result of plant etiolation.

The balance in the distribution of photoassimilates

Table 6. Pearson's linear correlation matrix for leaf levels of macro- and micronutrients, emergence speed index (ESI) and the biometric characteristics and quality of *P. gardneriana* Radlk seedlings grown on different substrates.

Substrate	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn	Na
SL[z]	0.17	0.33	0.03	0.47*	0.45*	0.43*	0.48*	0.19	0.12	-0.14	0.20	0.03
RCD[y]	0.08	-0.29	0.07	-0.06	-0.12	-0.21	0.01	0.03	0.08	0.16	-0.23	0.02
NL[x]	0.49*	0.51*	0.13	0.70*	0.52*	0.61*	0.65*	0.30	0.05	-0.16	0.34	-0.19
SDW[w]	0.35	0.57*	0.16	0.76*	0.64*	0.56*	0.71*	0.28	0.01	-0.17	0.10	-0.21
SDW[v]	0.26	0.24	0.13	0.44*	0.37	0.28	0.47*	0.16	0.12	-0.03	0.11	-0.16
RDW[u]	0.13	-0.23	0.08	-0.11	-0.17	-0.28	-0.15	-0.04	-0.09	0.02	-0.34	0.08
L[t]	0.29	0.51*	0.14	0.68*	0.61*	0.58*	0.64*	0.23	0.01	-0.23	0.18	-0.10
TDW[s]	0.32	0.35	0.16	0.55*	0.44*	0.33	0.50*	0.21	-0.01	-0.11	-0.02	-0.14
R/S[r]	-0.23	-0.72*	-0.11	-0.83*	-0.70*	-0.69*	-0.84*	-0.36	-0.21	0.04	-0.39	0.21

[z]Stem length; [y]Root collar diameter; [x]Number of leaves; [w]Leaf dry weight; [v]Stem dry weight, [u]Root dry weight; [t]Leaf area; [s]Total dry weight; [r]Ratio between root dry weight and shoot dry weights. *Pearson's correlation significant at the level of 5% probability.

Table 7. Ratio between stem length and root collar diameter (SL/RCD), root and shoot dry weight (R/S), stem length and number of leaves (SL/NL) and Dickson Quality index (DQI) of the *P. gardneriana* seedlings grown on different substrates.

Substrate	SL/RCD	R/S	SL/NL	DQI
	(cm mm^{-1})	(g g^{-1})	(-)	(-)
MP[y]+RH[x] (7:3)	5.61 [bz]	0.56 [b]	3.12 [ns]	0.438[ns]
FV[w]+SB[v]+RH (2:2:1)	5.52 [b]	0.70 [a]	3.29	0.428
FV+SB+RH (1:1:1)	5.67 [ab]	0.68 [a]	3.17	0.408
FV+SB+DCS[u] (3:1:6)	6.43 [a]	0.40 [c]	2.78	0.453
SB+CS[t]+CCM[s] (2:2:1)	6.44 [a]	0.42 [c]	2.95	0.430
LSD[r]	0.784	0.1154	0.463	0.144

[z]Means followed by the same letter are not significantly different from each other based on Tukey's test ($p < 0.05$); [y]MecPlant®; [x]Rice husks; [w]Fine vermiculite; [v]Subsoil; [u]Decomposed corn silage; [t]Coarse sand; [s]Composted cattle manure; [r]Least significant difference. [Ns]No significant differences between means.

between the shoot and the root system, as evidenced by the ratio of root and shoot dry weights (R/S), differed between seedlings when DCS and CCM were present at lower levels compared to the other substrates, and when the levels of DCS and CCM were lower, the presence of RH in the substrate resulted in higher R/S values. Saidelles et al. (2009) studied different levels of carbonized rice husks and reported that increasing the ratio of carbonized rice husks in the substrate increased the R/S ratio because, according to the authors, of a reduction in nutrient availability. The results observed in the present study are consistent with the data reported by these authors, where the addition of RH resulted in a higher R/S ratio and a lower concentration of nutrients. There was also a negative correlation between R/S and P, Ca, Mg, S and B; in other words, when the concentrations of these elements in the leaves were low, the plants invested more assimilate into root growth at the expense of the shoot in an attempt to absorb more of these nutrients from the soil.

The Dickson quality index (DQI) is considered one of the most complete indicators of seedling quality, but it did not indicate that there were differences between the *P. gardneriana* (A. DC.) Radlk. plants grown on the different substrates studied, demonstrating that the quality of the plants was similar.

Conclusions

(i) Plant growth was favored when composted cattle manure and decomposed corn silage were used in the substrates;
(ii) The use of composted cattle manure and decomposed silage provided a better nutrient supply for the plants;
(iii) Overall, the use of the substrates fine vermiculite+subsoil+decomposed corn silage at a ratio of 3:1:6 (v:v) and subsoil+coarse sand+composted cattle manure at a ratio of 2:2:1 (v:v) was more suitable for the

production of *P. gardneriana* (A. DC.) Radlk. seedlings.

Conflict of Interest

The authors have not declared any conflict of interest.

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