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BOTANY

Nutritional supplementation required by native Cerrado species development, in nursery

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ABSTRACT. The ecological restoration of Cerrado ecosystems involves challenges pertinent to the fertilization of the substrate for seedlings in nursery, which are often produced by a single type of substrate. However, habitat heterogeneity suggests that the species may have different nutritional requirements. The objective was to assess the effect of substrate fertilization and nutritional supplementation by leaf in developing seedlings of *Kielmeyera coriacea* Mart. & Zucc. *Eugenia dysenterica* (Mart.) and DC *Handroanthus impetiginosus* (Mart. ex DC.) Mattos. The experiment was implemented in a 3x3 factorial completely randomized design (three types of substrates x three levels of foliar fertilization), with ten replicates. The treatments were tested by analysis of variance. For *K. coriacea* and *H. impetiginosus,* it is recommended to use a substrate composed of Soil + Manure (2:1), for *E. dysenterica*, it is recommended to use the complete substrate. Foliar fertilization is not recommended for all species. Regarding the soil analysis, organic matter, phosphorus and calcium were determinants in the formation of fertility groups for each of the major components of the Principal Component Analysis.

Keywords: substrate; foliar fertilization; seedlings; tree species.

Exigência de suplementação nutricional no desenvolvimento de espécies nativas do Cerrado, em viveiro

RESUMO. A restauração ecológica dos ecossistemas do Cerrado envolve desafios pertinentes à fertilização do substrato para mudas em viveiro, sendo muitas vezes produzidas por um único tipo de substrado. A heterogeneidade de *habitats,* porém, indica que as espécies podem ter exigências nutricionais distintas. Objetivou-se, portanto, avaliar o efeito da fertilização do substrato e da suplementação nutricional via folha no desenvolvimento de mudas de *Kielmeyera coriacea* Mart. & Zucc., de *Eugenia dysenterica* (Mart.) DC e de *Handroanthus impetiginosus* (Mart. ex DC.) Mattos. O experimento foi implantado com a utilização de delineamento inteiramente casualizado, em esquema fatorial 3 x 3 (três tipos de substratos x três níveis de adubação foliar), com dez repetições. Os tratamentos foram submetidos a análise de variância. Para as espécies *K. coriacea* e *H. impetiginosus* recomenda-se utilizar substrato composto por Solo + Manure (2:1); já para a *E. dysenterica,* recomenda-se utilizar o substrato Completo, não se recomendando realizar a adubação foliar para todas as espécies. Em relação à análise do solo, a matéria orgânica, o fósforo e o cálcio foram determinantes na formação dos grupos de fertilidade para cada um dos principais componentes da Análise de Componentes Principais.

Palavras-chave: substrato; adubação foliar; mudas; espécies arbóreas.

Introduction

As native ecosystems worldwide become degraded by the expansion of human activities, the demand for ecological restoration also increases (Pilon, Buisson, & Durigan, 2018). With this intense exploitation of natural resources, there is great concern about environmental issues related to the excessive use of natural resources, being observed that the Cerrado is devoid of practices aimed at conservation of these resources, which has already lost about 50% of native vegetation cover (Lahsen, Bustamante, & Dalla-Nora, 2016).

While it is necessary to prevent activities that generate degradation of forest remnants, restoration and recovery of degraded areas are alternatives of extreme importance in the maintenance of forest ecosystems. Both, degraded and disturbed areas can be restored by using tree species native to the area, which transforms forest restoration into an emerging economic activity (Silva et al., 2017).

The Cerrado, as well as forests, is undergoing a rapid transformation and is undeniable the need for more information on the nutritional status of their species in different soil types (Haridasan & Araújo, 2005). Such information is of great importance during period of the seedlings in nursery.

Currently, there has been a growing demand for products and services aimed at the recovery of degraded and/or disturbed areas, especially for the production of seedlings of native forest species. This growing demand leads to the need to invest in research that enhance the production of seedlings at low costs and elevated quality that meet the objectives of the recovery of degraded areas (Kratka & Correa, 2015). One of the main factors for the implantation of forest stands is the seedling quality, which is directly related to the productivity and quality of the final product. Therefore, many efforts have been made to improve the quality and reduce production costs of seedlings (Trazzi, Caldeira, Passos, & Gonçalves, 2013).

The substrate is one of the inputs that have stood out in importance, due to its wide use in the production of seedlings (Kratz, Wendling, Nogueira, & Souza, 2013). It is an essential input that directly influences the seed germination, due to its structure, aeration, water holding capacity, pathogens, among others, which may favor or hinder seed germination (Silva et al., 2018; Guedes, Alves Gonçalves, França, Moura, & Santos, 2011; Moraes, Garcia, Souza, & Moreira, 2007). To produce seedlings of forest species, some factors should be considered, including the selection of the correct substrate and its fertilization, since interactions with acclimation factors during the production are important to ensure a quality end-product. With respect to seedlings of native species, there is a need for research that covers a long period of evaluation, avoiding the recommendations for treatment in an erroneous way.

In view of the above, the present study aimed to evaluate the effect of substrate fertilization and nutritional supplementation via leaf on the development of seedlings of tree species native to the Cerrado: *Eugenia dysenterica* (Mart.) DC, *Handroanthus impetiginosus* (Mart ex DC.) Mattos and *Kielmeyera coriacea* Mart. & Zucc. and determine which nutrients available in the substrate have a greater correlation with the growth of these seedlings.

Material and methods

The experiment was conducted in Brasilia, Federal District, in a seedling nursery for production of tree species from the company MataVirgem®, located at coordinates 15º34.345'S and 47º59.995'W and altitude of 1,287 m. According to Alvares, Stape, Sentelhas, Gonçalves, and Sparovek (2014), the climate in the region is Aw, with two well-defined seasons.

We adopted a factorial completely randomized design with two factors consisting of the substrate in three levels; and foliar fertilization, also in three levels, totalizing nine treatments. The treatments were applied in three species of native to the Cerrado (*Eugenia dysenterica* (Mart.) DC, *Kiekmeyera coriacea* Mart. & Zucc. and *Handroanthus impetiginosus* (Mart. ex DC.) Mattos), which had the seeds collected in remnants of Cerrado in the vicinity of Brasília, totalizing 27 plots with ten replicates. Each repetition consisted of eight subjects, for a total of 2,160 plants studied. Seeds were collected in Cerrado remnants in the vicinity of Brasília, Federal District.

We evaluated three types of substrates: 1 – Red latosol; 2 – Soil + Manure in the ratio 2:1; 3 – Soil + Manure in the ratio 2:1 + 2.2 kg NPK (10 – 10 – 10) per cubic meter of substrate + 1.3 kg limestone per cubic meter of substrate. To facilitate the visualization of the results in figures and tables, substrates 1, 2 and 3 were denominated as Soil, Soil + Manure and Complete, respectively.

In foliar fertilization, the commercial product used was Niphokam® 10–08–08, soluble in water, with application of three doses of foliar supplementary fertilization: NPK applied weekly, as recommended by the manufacturer for perennial species; NPK applied quarterly; and control, without foliar application of NPK. The fertilization used was 1.0 mL commercial product for every 1,000 mL water, being applied at weekly intervals after the emergence of the first pair of leaves, according to the recommendation of the manufacturer. This dosage represents the application of approximately 1 L solution to about 720 plants, sufficient to cover the entire leaf area by spraying the solution.

We used containers made of nursery bags with dimensions 14 x 20 cm (1,248 cm^3), arranged in beds without direct contact with the ground, allocated upon a black plastic tarpaulin in a greenhouse with 50% shading cloth. In the experiment, we used the technique of seedlings pricking out, which consists of sowing in sandbox and subsequent transplanting seedlings to the substrate in the nursery bag.

The plants of the experiment were measured in height of the aerial part, referring to the level of the substrate to the apical bud and stem diameter at the substrate level at the beginning and ten months after transplanting. The instruments used were millimeter ruler and digital caliper accurate to two decimal places. The increase in height and stem diameter obtained by subtracting the measurements at the beginning and end of the evaluations was subjected to analysis of variance ($p \leq 0.05$), the means were subjected to the Tukey's test, both at 5% probability.

At the end of the analysis, for each substrate and species, there were a total of nine samples, each sample comprising simple thirty samples of the same volume. The soil analysis was performed according to Sousa and Lobato (2004), who present the interpretation of Cerrado soils as a reference for recommendations on crops and may be applied to nutrient availability in each treatment and determine the influence of chemical variables of the soil on the growth of different species, in different substrates.

To assess the group of species and substrates, relating them to the amount of nutrients available in each type of substrate, a Principal Component Analysis was applied (PCA). To determine which soil chemical variables presented higher correlation with the development of the seedlings, a Canonical Correlation Analysis was performed (CCA) together with the Monte Carlo permutation test (MCP), with 10,000 randomizations.

Results and discussion

According to the analysis of variance, considering the increase in shoot height, there was a significant difference ($p \leq 0.05$) between the substrates for all species tested (Table 1). Regarding the treatments related to the foliar fertilization, there was a significant difference only for K. coriacea. As for the interaction between treatments, there was a significant difference for the K. coriaceae and E. dysenterica. For the increase in stem diameter, there was a significant difference by the F-test for substrate and interaction of treatments for E. dysenterica. In turn, for H. impetiginosus, there was a significant difference for both treatments.

The result of the Tukey's test for shoot height and stem diameter for different substrates (Table 2), showed that the substrate Soil + Manure treatment presented better results for the production of seedlings of *K. coriaceae* and *H. impetiginosus*. For *K. coriacea*, there was no significant difference in stem diameter but significant difference in shoot height, with better results in the Soil + Manure and Complete substrates, thus being recommended the Soil + Manure substrate. For *E. dysenterica,* the Complete substrate was the indicated to the same variable.

As for foliar fertilization, it was evidenced that, by Tukey's test at 5% probability, for the variables analyzed, it is not recommended to perform foliar fertilization until 300 days of age, hence the need for longer studies on *K. coriaceae* and *E. dysenterica,* and at some point, nutritional supplementation may be required through foliar fertilization. However, some species show no significant increase in development when subjected to fertilization, which may be a feature of their genetic variability in response to low natural fertility of the soil to which they are adapted (Lima, Tamiozzo, Palomino, Petter, & Marimon-Junior, 2015).

Table 1. F-test results, at 5% probability level, for the variables increase in shoot height and stem diameter for different treatments and interactions for each species studied.

Specie	SV	DF	F. ratio (H)	F. ratio (D)
K. coriacea	Foliar fertilization	2	4.99 *	2.89 n.s.
	Substrate	2	49.62 *	0.58 n.s.
	Foliar fertilization x Substrate	4	3.55 *	1.75 n.s.
	Residue	81		
E. dysenterica	Foliar fertilization	2	0.93 n.s.	1.35 n.s.
	Substrato	2	119.54 *	9.99 *
	Foliar fertilization x Substrate	4	4.65 *	16.65 *
	Residue	81		
H. impetiginosus	Foliar fertilization	2	2.19 n.s.	6.31 *
	Substrato	2	81.37 *	103.43 *
	Foliar fertilization x Substrate	4	0.82 n.s.	1.43 n.s.
	Residue	81		

* Significant at 5% probability; n.s: non-significant at 5% probability; SV: source of variation; DF: Degree of freedom; H: increase in shoot height; D: increase in stem diameter.

The superiority of bovine manure can be explained by the higher content of nitrogen (N) and potassium (K) in these sources. Such elements are directly involved in photosynthesis and respiration, which possibly resulted in an increased performance of seedlings when bovine manures were incorporated into the substrate (Mendonça et al., 2017).

With addition of bovine manure, there is a considerable increase in phosphorus levels available in the substrate. According to Lopes (1989), phosphorus promotes early root formation, early root growth, improves the efficiency of water usage and, when at a high content in the soil, helps to keep its absorption by seedlings, even under high soil moisture conditions.

Substrates containing 33.33% or more of bovine manure promote best physical structure to the substrates (aeration, moisture retention and porosity) and facilitate nutrient uptake by seedlings (Costa, Oliveira, Espírito Santo, & Leal, 2012; Costa, Martins, Faria, Jorge, & Leal, 2014). Camargo, Pires, Maldonado, Carvalho, and Costa (2011) reported that manure contributes to moisture retention and supply of the nutrients necessary for the plant, this factor leads to the traditional use of this material in the production of seedlings of tree species, fruit growing species and coffee plants.

For interactions between treatments, F-test evidenced significant effects only for *K. coriaceae* and *E. dysenterica.* The interaction of substrate treatments within each level of foliar fertilization demonstrated that *K. coriaceae* showed better results for increase in height for the substrate Soil + Manure in all interactions; as for the diameter, there were no significant difference between interactions.

For *E. dysenterica,* the substrate Soil + Manure showed better results for the increase in height when performing weekly foliar fertilization and in the absence of foliar fertilization; as for the Complete substrate, it showed better results for increase in height and diameter when performing foliar fertilization in a three-month interval (Table 3) and only the interactions significantly different by Tukey's test are represented in the table.

As the interaction between treatments related to foliar fertilization within each substrate level, we observed better results in the absence of foliar fertilization in the substrates Soil + Manure and Complete. Furthermore, the Soil substrate obtained the best results when the foliar fertilization was performed on a weekly basis.

Leaf cells, like those of the roots, absorb the mineral elements from the apoplast, and these have to cross the plasma membrane, with ultrafilter properties, with the difference that the leaf absorption is much slower than the root, since the small pores of the leaf (existing in the layers of the cuticle and wax) and the stomata allow a restricted entrance of nutrients. The nutrient absorption rate by the leaves also depends on the nutritional status of the plant (Kerbauy, 2004).

For *K. coriaceae* species, significant differences were detected only for the increase in height in the interaction with the substrate Soil + Manure, being obtained better results when foliar application was not carried out (Table 4). For *H. impetiginosus*, there were no significant differences in the interactions between treatments.

Table 2. Tukey's test at 5% probability level for the variables increase in shoot height and stem diameter in the different treatments, referring to species *Eugenia dysenterica*, *Handroanthus impetiginosus* and *Kielmeyera coriacea*.

Treatment		Increase in height (cm)			Increase in diameter (mm)		
		K. coriacea	*E. dysenterica*	*H. impetiginosus*	*K. coriacea*	*E. dysenterica*	*H. impetiginosus*
Substrate	Soil + Manure	1.70 a	3.55 b	12.43 a	0.58 a	0.52 a	2.06 a
	Complete	1.57 a	4.10 a	9.53 b	0.61 a	0.52 a	1.80 a
	Soil	0.81 b	1.15 c	0.83 c	0.52 a	0.35 b	0.42 b
Foliar fertilization	Weekly	1.48 a	2.92 a	6.46 a	0.50 a	0.48 a	1.18 b
	Control	1.40 ab	3.08 a	8.13 a	0.53 a	0.42 a	1.59 a
	Quarterly	1.19 b	2.8 a	8.22 a	0.68 a	0.48 a	1.51 a

* Mean values followed by different letters in the same column are significantly different by Tukey's test, at 5% probability.

Table 3. Tukey's test at 5% probability for each substrate within each level of foliar fertilization level tested for *E. dysenterica* and *K. coriaceae*.

Specie	Interaction between treatments	Interaction for weekly foliar fertilization				Interaction for control foliar fertilization				Interaction for quarterly foliar fertilization			
		Height (cm)	Sd (cm)	Diameter (mm)	Sd (mm)	Height (cm)	Sd (cm)	Diameter (mm)	Sd (mm)	Height (cm)	Sd (cm)	Diameter (mm)	Sd (mm)
E. dysenterica	Soil + Manure	3.53 a	0.95	0.369 b	0,27	3.82 a	0.96	0.558 a	0,08	3.29 b	0.88	0.620 a	0.18
	Complete	3.49 a	0.97	0.414 b	0,15	4.55 a	0.83	0.521 a	0,21	4.24 a	0.94	0.641 a	0.13
	Soil	1.74 b	0.50	0.655 a	0,11	0.85 b	0.33	0.177 b	0,18	0.87 c	0.25	0.211 b	0.11
K. coriacea	Soil + Manure	2.05 a	0.50	n.s	-	1.69 a	0.30	n.s	-	1.35 a	0.42	n.s	-
	Complete	1.46 b	0.43	n.s	-	1.62 a	0.25	n.s	-	1.63 a	0.43	n.s	-
	Soil	0.95 c	0.36	n.s	-	0.9 b	0.21	n.s	-	0.58 b	0.37	n.s	-

* Means followed by different letters are significantly different by Tukey's test, at 5% probability; n.s: non-significant; Sd: Standard deviation.

Higher values of mortality were related to Complete substrate with 20.42; 6.67; 11.67% for *K. coriacea*, *E. dysenterica* and *H. impetiginosus,* respectively (Figure 1). Soil substrate showed the lowest mortality rate, demonstrating favorable conditions for the adaptation of seedlings after the completion of the transplanting technique. Oliveira et al. (2014) evaluated different percentages of manure in the substrate composition on the production of seedlings *Dipteryx alata,* and obtained greater mortality related to the larger amount of manure. The same authors also mentioned that higher mortality may be associated with the process of decomposition and possible fermentation, causing losses in the formation of the root system. Thus, manure must be properly tanned before introduced into the composition of the substrate, avoiding the increase in the mortality of seedlings.

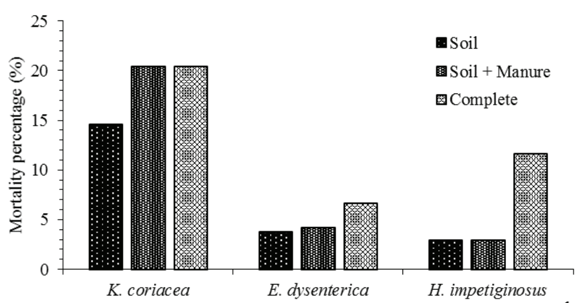

Figure 1. Mortality rate of *Kielmeyera coriacea, Eugenia dysenterica* and *Handroanthus impetiginosus* on the different substrates tested.

The substrate Soil + Manure showed different behavior regarding the mortality rate for each species: *H. impetiginosus* showed lower mortality rate, which is similar to that of the substrate Soil (2.92%); for *E. dysenterica*, this substrate showed values in the mortality rate of 4.17%, lower than the Complete substrate and higher than the Soil substrate; and for the *K. coriacea* species presented a mortality rate equivalent to the Complete substrate of 20.4%.

Associating the mortality rate with the results of the tests of means for the variables increase in shoot height and diameter, it is possible to state that for K. coriacea, although the Soil + Manure substrate was adequate for the increase in height, this variable had a lower importance in decision criteria, as it had a difference of only 9 mm from the Soil substrate; therefore, it is recommended the Soil substrate for the production of K. coriacea seedlings; this substrate is also recommended for the increase in diameter, in addition to the lower mortality rate. Likewise, this substrate (Soil+Manure) is recommended for the production of E. dysenterica seedlings, with only 55 mm difference between this and the Complete substrate.

The results of the soil analysis indicated that all substrates were classified as clayey, according to the textural classes of soil described by Sousa and Lobato (2004) for the Cerrado soil, where the percentages of clay had values between 44 to 51%, silt between 1 and 3% and sand between 47 and 56% for the different types of substrates. After 10 months in the nursery, the substrates that showed organic matter, calcium and magnesium in adequate amounts were the substrates Soil+Manure and Complete; for the Soil substrate, it was observed a low amount for these variables. Thus, the base saturation indicates that the substrates Soil+Manure and Complete are classified as normal (fertile), as they presented base saturation (V) greater than 50%; and the Soil substrate was classified as dystrophic (low fertility).

As for phosphorus (P) and potassium (K), in general, the Soil+Manure substrate presented better results, with more adequate contents of these macronutrients when compared to the Complete substrate, which presented higher amounts of phosphorus, above the recommended for agricultural crops. The results of chemical analysis of soil is presented in Table 5.

There was a significant increase in fertility of the Soil + Manure substrate with the addition of manure, reaching amounts of Ca and K+Mg near to those of the Complete substrate. It was also observed an increase in P with the addition of manure, with intermediate levels when compared to Soil and Complete substrates. Organic fertilizers, such as tanned bovine manure, are nutrient sources often incorporated into substrates, acting significantly on improving the physical and chemical attributes (Artur, Cruz, Ferreira, Barretto, & Yagi, 2007).

Table 4. Tukey's test at 5% probability for foliar fertilization within each substrate level tested, related to *Eugenia dysenterica* and *K. coriaceae*.

Species	Interaction between treatments	Substrate Soil + Menure		Complete Substrate				Substrate Soil			
		Diameter (mm)	Sd (mm)	Height (cm)	Sd (cm)	Diameter (mm)	Sd (mm)	Height (cm)	Sd (mm)	Diameter (mm)	Sd (mm)
E. dysenterica	Weekly	0.369 b	0.27	3.49 b	0.97	0.414 b	0.15	1.74 a	0.50	0.655 a	0.11
	Quarterly	0.620 a	0.18	4.24 ab	0.94	0.614 a	0.13	0.87 b	0.25	0.211 b	0.11
	Control	0.556 a	0.08	4.55 a	0.83	0.521 ab	0.21	0.85 b	0.33	0.177 b	0.18
		Height (cm)	Sd (cm)	Height (cm)	Sd (cm)	Diameter (mm)	Sd (mm)	Height (cm)	Sd (mm)	Diameter (mm)	Sd (mm)
K. coriacea	Weekly	2.05 a	0.50	n.s	-	n.s	-	n.s	-	n.s	-
	Control	1.69 ab	0.30	n.s	-	n.s	-	n.s	-	n.s	-
	Quarterly	1.35 b	0.42	n.s	-	n.s	-	n.s	-	n.s	-

* Means followed by different letters are significantly different by Tukey's test, at 5% probability; n.s: non-significant; Sd: Standard deviation.

With the exclusion of the least relevant chemical variables, the principal component analysis (PCA) showed the formation of groups in relation to the different types of substrates. The first two principal components explained together 87.8% total variability (Table 6). The choice of the number of PCA components used for data interpretation is an empirical criterion, where some authors recommend using a set of components that together accumulate at least 70% of the total (Rencher, 2002).

Table 6. Eigenvalues of the components and their respective percentages of variance formed in the PCA.

Component	Eigenvalue	Variance explained (%)
1	4.3462	72.44
2	0.9232	15.39

The variables most correlated with the first component and their correlation values were: Organic matter (OM) (0.987); Calcium (Ca) (0.976), Phosphorus (P) (0.857), Potassium (K) (0.827) and pH (0.823). The variables most correlated with the second main component and their respective correlation values were: H+Al (0.718) and Potassium (K) (-0.496).

The resulting plot of the first two principal components (Figure 2) showed a tendency to the formation of three groups, one formed by the species on the Soil substrate, in which *K. coriacea* was not grouped, remaining isolated by presenting lower pH value in the substrate compared to *E. dysenterica* and *H. impetiginosus.* In general, species on the Soil substrate were less associated with chemical parameters of the soil, and *E. dysenterica* and *H. impetiginosus* showed lower association with phosphorus (P) and potassium (K) and *K. coriacea,* lower association with pH.

The second group is formed by Soil+Manure substrate and the third by the Complete substrate associated with high content of organic matter, in which the species associated with the Complete substrate exhibited higher values of phosphorus, potassium, calcium, pH, organic matter and remained further away from the vectors of soil chemical variables.

For the analysis of interactions between the substrate chemical variables (phosphorus, potassium, calcium, magnesium and organic matter) and the variables related to measurement of seedlings, which indicates how correlated they are, a Canonical Correlation Analysis was applied. In this analysis, it can be seen that the eigenvalues of the axes 1 and 2 were low for all species (Table 7).

Low eigenvalues indicate the existence of short gradients, lower than 0.3, which are of low relevance in determining the variation in the data, considered homogeneous data (Felfili, Carvalho, Libano, Venturoli, & Pereira, 2007). That is, the correlation was not able to accurately explain the distribution of the species in each substrate in the gradient. The Monte Carlo permutation test with 10,000 randomizations was not significant ($p > 0.01$), which indicated that for the two axes, the gradients of species in each substrate are random considering this database.

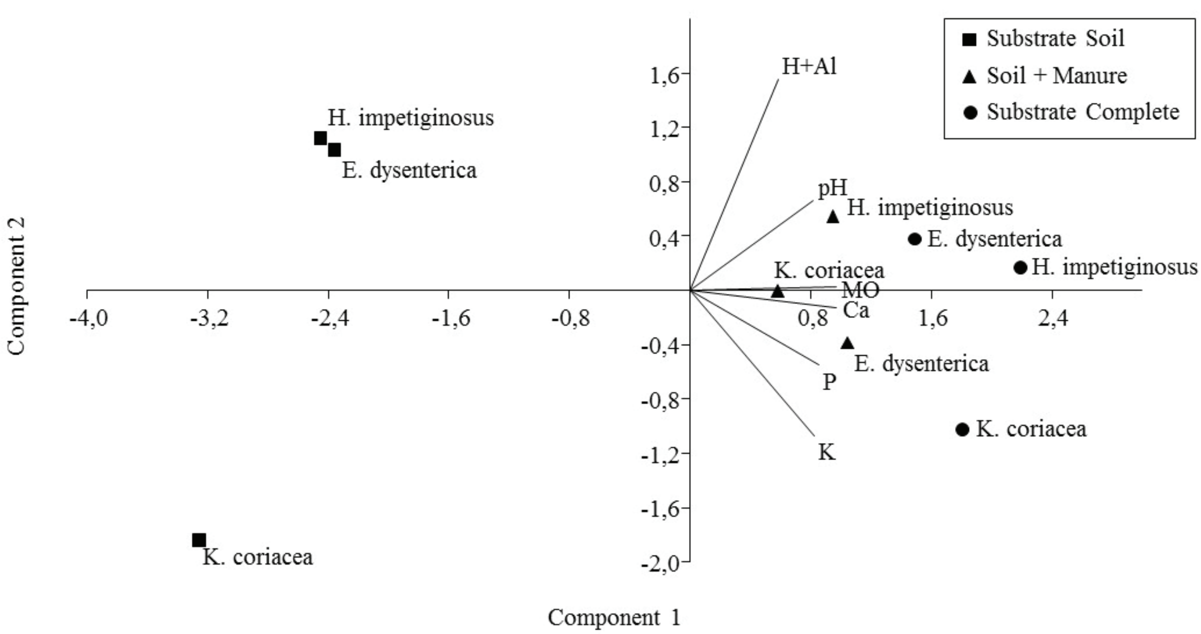

Figure 2. Diagram generated by PCA with reference to the first two principal components.

Table 5. Results of soil analysis for three native species studied *K. coriacea* (Pau Santo), *E. dysenterica* (Cagaita) and *H. impetiginosus* (Ipê roxo) on different substrates tested.

Substrate	Species	pH (CaCl2)	P	K	H + Al	Ca + Mg	SB	OM	V
			-----mg dm^{-3}-----		--------- cmolc dm^{-3} ---------			dag kg^{-1}	%
Soil + Manure	*K. coriacea*	5.7	13.8	45	1.9	3.68	3.8	3.2	66.64
	E. dysenterica	5.7	36.8	49	1.9	3.18	3.31	3.4	63.50
	H. impetiginosus	5.9	12.4	40	1.9	3.71	3.81	3.2	66.74
Soil	*K. coriacea*	5.5	2.1	27	1.7	0.61	0.68	1	28.54
	E. dysenterica	5.6	1.2	13	1.9	0.68	0.71	1.3	27.29
	H. impetiginosus	5.6	2.1	10	1.9	0.59	0.62	1.3	24.47
Complete	*K. coriacea*	5.7	56.8	61	1.9	3.66	3.82	3.2	66.76
	E. dysenterica	5.9	40.1	35	1.9	3.45	3.54	3.7	65.07
	H. impetiginosus	6	48	44	1.9	4.02	4.13	3.5	68.50

pH: potential of hydrogen; P: phosphorus; K: potassium; H+Al: Potential acidity; Ca + Mg: calcium + magnesium; SB: sum of bases; OM: organic matter; V: base saturation.

Table 7. Summary of the Canonical Correlation Analysis for the different species studied.

CCA	*K. coriacea*		*E. dysenterica*		*H. impetiginosus*	
	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2
Eigenvalue	0.00621	0.00000	0.00229	0.00004	0.01458	0.00011
p (Monte Carlo for eigenvalue)	0.838	0.5082	0.4922	0.3295	0.4922	0.3295

Conclusion

For *Kielmeyera coriacea* and *Handroanthus impetiginosus*, it is recommended to use a substrate composed of Red Latosol and Manure in the proportion of 2:1.

For *Eugenia dysenterica*, it is recommended to use Complete substrate composed of manure in the ratio 2:1+ 2.2 kg NPK (10-10-10) per cubic meter of substrate + 1.3 kg limestone per cubic meter of substrate.

The addition of manure to the substrate is essential for the production of seedlings *of Kielmeyera coriacea, Eugenia dysenterica* and *Handroanthus impetiginosus*.

It is not recommended to perform the foliar fertilization in plants for the studied species.

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