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# Liming and phosphate fertilization in seedlings production of cagaiteira

## *Calagem e adubação fosfatada na produção de mudas de cagaiteira*

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**ABSTRACT:** The cagaiteira (*Eugenia dysenterica* DC.) is an important fruit species native from Brazilian Cerrado that has economic potential for food and pharmaceutical sectors and the recovery of degraded areas. Knowledge about crop management is still limited, including fertilization methods. This study aimed to evaluate the effect of lime and phosphorus (P) application on nutrition, growth, dry matter production and physiological aspects of cagaiteira seedlings. The experiment was conducted in a greenhouse, using a randomized block design with three replications, in a 5x4 factorial scheme, five base saturation levels (24.5, 40.0, 60.0, 80.0 and 100.0%) and four P rates (0, 100, 200 and 400 mg $dm^{-3}$)**. At 180 days after** transplanting, gas exchange, biometrics (diameter, height and leaf area), dry mass production, seedling quality (Dickson Quality Index - DQI) and nutrient content were evaluated. The results were subjected to analysis of variance ($p<0.05$) and regression model adjustments. The growth and physiology of *Eugenia dysenterica* DC seedlings are not influenced by liming; however, the application of lime positively influences the B content in the plants. Phosphate fertilization increases growth in height, with an estimated rate of 245 mg $dm^{-3}$ of P indicated to produce cagaiteira seedlings, since at this dose is estimated that the plant will be taller. In general, cagaiteira proves to be a species that develops well in acid soil conditions and with low availability of P.

**Keywords:** Brazilian savanna; *Eugenia Dysenterica*; Mineral nutrition; Native fruits; Base saturation.

**RESUMO:** A cagaiteira (*Eugenia dysenterica* DC.) é uma importante espécie frutífera nativa do Cerrado brasileiro que apresenta potencial econômico para o setor alimentício, farmacêutico e recuperação de áreas degradadas. O conhecimento sobre o manejo da cultura ainda é restrito, incluindo os métodos de fertilização. Este estudo objetivou avaliar o efeito da aplicação de calcário e de fósforo (P) na nutrição, no crescimento, na produção de matéria seca e nos aspectos fisiológicos das mudas de cagaiteira. O experimento foi conduzido em casa de vegetação, em delineamento experimental de blocos casualizados com três repetições, em esquema fatorial 5x4, cinco níveis de saturação por bases (24,5; 40,0; 60,0; 80,0 e 100,0%) e quatro doses de P (0, 100, 200 e 400 mg $dm^{-3}$). Aos 180 dias após o transplantio, foram avaliadas as trocas gasosas, a biometria (diâmetro, altura e área foliar), a produção de massa seca, a qualidade das mudas (índice de qualidade de Dickson - DQI) e o conteúdo de nutrientes. Os resultados foram submetidos à análise de variância ($p<0,05$) e aos ajustes de modelos de regressão. O crescimento e a fisiologia de mudas

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de *Eugenia dysenterica* DC não são influenciados pela calagem; entretanto, a aplicação de calcário influencia positivamente o teor de B nas plantas. A adubação fosfatada aumenta o crescimento em altura, com uma taxa estimada de 245 mg dm-³ de P indicada para a produção de mudas de cagaiteira, pois nesta dose estima-se que a planta estará mais alta. Em geral, a cagaiteira mostra-se uma espécie que se desenvolve bem em condições de solo ácido e com baixa disponibilidade de P.

**Palavras-chave:** Cerrado; *Eugenia Dysenterica;* Nutrição mineral; Frutos nativos; Saturação de bases.

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## INTRODUCTION

Cagaiteira (*Eugenia dysenterica* DC.) is a native plant from Brazilian Cerrado with wide use in the pharmaceutical industry (Oliveira *et al*., 2020), with potential nutraceutical use of the fruit pulp (Justino *et al*., 2020), therapeutic (Araujo *et al*., 2021a; Araujo *et al*., 2021b) and a promising alternative for the topical treatment of skin infections using emulsions with extracts of its leaves (Nunes *et al*., 2018; Silva *et al*., 2020). Additionally, its benefits have also been tested in the industry, such as the use of ethanolic cagaita extract as an antioxidant in soybean methyl biodiesel, replacing quercetin (Rial *et al*., 2020), as well as is indicated for planting in places that are in recovery processes of degraded areas (Nascimento *et al*., 2020).

Despite its potential, the commercial production of seedlings of the specie is still restricted, especially due to limited knowledge about its nutritional requirements (Bessa *et al*., 2016). The Brazilian Cerrado offers the endemic species existing there very adverse conditions for survival, such as water deficit, acidity, aluminum toxicity and low soil fertility. The practice of liming aims to minimize these effects, with the base saturation method (V %) being predominantly used in the recommendations, however the ideal V % to produce cagaiteira seedlings has not yet been defined. In addition, the availability of phosphorus (P) is one of the most limiting in Cerrado soils, and it can be increased by adequate soil correction by applying limestone. P plays an important role in plants; in respiration, storage, transport, and use of energy in the photosynthetic process, also acting in protein synthesis and enzyme metabolism (Novais *et al*., 2007; Van Raij, 2011). Thus, establishing an adequate supply of P for the best development of cagaiteira seedlings is of great importance in allowing greater knowledge about their nutritional requirements in soil with different base saturations.

Although the natural conditions of the Cerrado are limiting to the development of most endemic plants, many native species developed adaptive mechanisms to be able to develop under adversity (Furquim *et al*., 2018). However, studies that identify such mechanisms are still scarce, and it is necessary to carry out studies that seek to verify what they are and how they work. Added to this, the fact that native Cerrado species are tolerant to the low natural chemical fertility of the soil does not eliminate the possibility of responses to fertilization (Duboc; Guerrini, 2009). Preliminary study carried out by Reis *et al.* (2020), evaluating the development of seedlings of *E. dysenterica*, indicated that fertilization with nitrogen (N) (50 mg dm$^{-3}$) and P (200 mg dm$^{-3}$) provided, in general, better development of the seedlings.

In this way, for the efficient production of seedlings, liming and phosphorus fertilization can favor the obtaining of plants with higher quality and adequate nutritional status. Given the above, the present study aimed to evaluate the effect of lime and P application on nutrition, physiology, growth, and dry matter production of cagaiteira seedlings grown in Cerrado soil.

## MATERIAL AND METHODS

The experiment was carried out in a greenhouse at the Department of Agricultural Sciences at the Federal University of São João del Rei (UFSJ), Campus Sete Lagoas (CSL) (Sete Lagoas-MG; 19º28' S, 44º11'W and 800 m of altitude). The survey was carried out for 180 days, between March and September 2017.

The experimental was design in randomized blocks, with three replications, in a 5x4 factorial scheme, five base saturation levels – V (24.5, 40, 60, 80 and 100%) and four phosphorus doses (0, 100, 200 and 400 mg dm$^{-3}$ of P). The lowest level of base saturation (24.5 %) represented the natural condition of the soil and the other levels were obtained with the application of four limestone doses, estimated by the base saturation method (Catani; Gallo, 1955) using the reagents calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) (p.a.) in the ratio 3:1 (Ca:Mg). For the P application, the mono-ammonium-phosphate (MAP) p.a. source was used. The experimental plot was composed of two polyethylene pots with one plant each, filled with 3 L of RED OXISOL Distrofic clay (Brazilian Soil Classification System - SiBCS, Santos *et al.*, 2018) – Ferralsol (USS Working Group WRB, 2022) – with low natural chemical fertility (Table 1), collected (20-40 cm) at UFSJ-CSL.

**Table 1.** Physical and chemical characterization of the soil collected (20-40 cm) in the Cerrado area, in the central region of Minas Gerais - Brazil, used in the experiment in pots in a greenhouse.

| pH | SOM | P | K | Ca | Mg | Al | H+Al | SB | t | T |
|---|---|---|---|---|---|---|---|---|---|---|
| $H_2O$ | % | ..mg dm$^{-3}$.. | | ...............cmol$_c$dm$^{-3}$............... | | | | | | |
| 5.5 | 0.86 | 1.3 | 3.9 | 0.93 | 0.1 | 0.3 | 3.2 | 1.04 | 1.34 | 4.24 |
| V | m | S | B | Cu | Fe | Mn | Zn | Clay | Silt | Sand |
| .........%......... | | ............ mg dm$^{-3}$............ | | | | | | ..........g kg$^{-1}$.......... | | |
| 24.53 | 22.39 | 1.58 | 0.01 | 1.24 | 26.35 | 11.24 | 0.71 | 770 | 110 | 120 |

*pH in water; P, K, Cu, Fe, Mn and Zn extraction with Mehlich-1; Ca, Mg and Al extraction with KCl 1 mol L$^{-1}$; B extraction with hot water; H + Al extraction with SMP and S extraction with monocalcium phosphate in acetic acid. SOM oxidation: $Na_2Cr_2O_7$ 4N + $H_2SO_4$ 10N. pH – Hydrogenionic Potential; SOM – Soil Organic Matter; P – Phosphorus; K – Potassium; Ca – Calcium; Mg – Magnesium; Al – Aluminum; H+Al – Potential Acidity; SB – Sum of Bases; t – effective CEC; T – potential CEC; V – Base Saturation; m – Aluminum Saturation; S – Sulfur; B – Boron; Cu – Copper; Fe – Iron, Mn – Manganese; Zn – Zinc.

The acidity correctives were incorporated into the dry and sieved soil (5 mm) of each pot, moistened and incubated for 30 days. After this period, a new soil analysis was carried out to verify the base saturation levels reached (Table 2). Phosphate fertilizer was incorporated into the soil shortly after the corrective incubation period, in a single application, immediately before planting. The other nutrients were applied as a solution, on the soil surface, at the following doses (mg dm$^{-3}$): N = 300; K = 300; S = 60; B = 0.5; Cu = 1.5; Zn = 5.0 and Mo = 0.1. Nutrient rates were adjusted based on other greenhouse studies (Malavolta, 1980; Novais *et al.*, 1991; Resende *et al.*, 2012). The seedlings were transplanted at 90 days, when the MAP doses were applied. N was supplemented with ammonium nitrate for standardization in total 300 mg dm$^{-3}$ of N. A cover was made at 120 days (30 days after transplanting). K was applied with potassium sulfate and potassium chloride sources. To supply all nutrients, were applied pure reagents for analysis (p.a.).

**Table 2.** Soil Characterization used in the experiment after incubation with acidity correctives.

| V Calculated* | V Reached** | pH | Ca | Mg | Al | SB |
|---|---|---|---|---|---|---|
| ..................% .................. | | | | ......……cmol$_c$ dm$^{-3}$……..... | | |
| Natural (24.53) | 24.53 | 5.5 | 0.93 | 0.10 | 0.30 | 1.04 |
| 40 | 39.30 | 5.7 | 1.66 | 0.16 | 0.07 | 1.85 |
| 60 | 53.69 | 6.0 | 2.20 | 0.26 | 0.06 | 2.49 |
| 80 | 60.53 | 6.6 | 2.77 | 0.34 | 0.07 | 3.14 |
| 100 | 69.15 | 6.9 | 3.26 | 0.40 | 0.05 | 3.69 |

* V2 values used in the calculation of liming requirements; ** V values reached after 30 days of incubation of correctives in the soil.

The seeds used in seedling production were obtained in October 2016, from mature fruits of *E. dysenterica* DC collected from mother plants in Fortuna de Minas - MG. These were pulped manually, and the seeds washed in water and placed to dry in the shade (48 h). Sowing was done in tubes (110 cm$^3$) containing Bioplant commercial substrate and maintained under constant manual irrigation, maintaining field capacity in the seedling nursery at UFSJ-CSL. The emergence occurred 40 days after sowing and three months after the emergence of the seedlings, the seedlings were transplanted into the vases with the applied treatments.

Immediately after transplanting, the height – H (cm) was measured with the aid of a graduated ruler and the stem diameter – SD (mm) with a Lee Tools 684132 digital caliper. After 180 days, the same measurements were taken and calculated the growth increment from the difference between the first and the last measurement.

The physiological characterization was performed using the photosynthesis analyzer from CID, Inc., model CI-340 Handheld Photosynthesis System, by measuring the variables net photosynthesis rate ($A$) in $\mu$mol m$^{-2}$ s$^{-1}$; sweating rate ($E$), in mmol m$^{-2}$ s$^{-1}$; and leaf stomatal conductance ($g_s$) in mmol m$^{-2}$ s$^{-1}$. Through the ratio between variables $A$ and $E$, the water use efficiency (WUE) was estimated. These evaluations took place 180 days after transplanting, between 9 am and 11 am, the period of greatest peak of photosynthesis in fully expanded leaves, with three readings per treatment. The device has some fixed parameters such as the atmospheric pressure of the analysis site (ATM), which is 92.79 kPa; the flow rate set for the analyzer (FLOW) at 0.30 L min$^{-1}$ and the mass flow rate (W) set at 0.30 mol m$^{-2}$ s$^{-1}$, with a variation of $\pm$ 0.01.

After the last measurement, the plants were removed from the pots and separated into shoots and roots. The total leaf area (LA) of seedlings was estimated using ImageJ software. The roots were sieved (2 mm) from the soil and washed in running distilled water. Total dry matter mass (TSM), shoot dry matter mass (SDM) and root dry matter mass (SRM) were obtained by drying in an oven with forced air circulation at 65 °C for 96 h. Additionally, the RDM/SDM ratio, which indicates seedling robustness, and the Dickson Quality Index [DQI=TDM/(H/SD) + (SDM/RDM)] (Dickson; Leaf; Hosner, 1960) were estimated.

The SDM was ground and sent to the laboratory for determination of nutrient content in the shoot. In the nitric-perchloric extract, P levels were determined by colorimetry; Ca, Mg, K, Cu, Fe, Mn and Zn by atomic absorption spectrophotometry; S by barium sulfate turbidimetry; Total N by the semi-micro Kjeldahl method; and B, after dry digestion, by colorimetry (curcumin method) (Malavolta; Vitti; Oliveira, 1997). The content results were multiplied by the respective SDM values to obtain the nutrient accumulation in each treatment.

All the results obtained were submitted to residual analysis to verify the normality and homogeneity of the variance, when the assumptions were not met, the Box Cox data transformation was performed. Subsequently, analysis of variance ($p \leq 0.05$) was performed to verify the isolated effect of the factors (lime and P doses) and the interaction between them in the response variables. When significance was found, adjustment was made to the linear, quadratic and cubic regression models, and those models with significance ($p < 0.05$) and with the highest coefficient of determination ($R^2$) were chosen. The calculations were performed using the "RStudio" program (R Core Team, 2021).

## RESULTS AND DISCUSSION

The doses of P significantly influenced the increment in H of the cagaiteira seedlings, as the doses applied to the soil increased, with the highest increment in H (7.02 cm) achieved with the estimated dose of 245 mg $dm^{-3}$ of P, and from that dose onwards there was a decrease in the value of the variable (Figure 1a). The doses of limestone and P applied, and the interaction between them, did not provide a significant difference in the increment of stem diameter (SD) and leaf area (LA) (Figures 1b and 1c), shoot dry matter (SDM), roots (RDM) and total (TDM), the SDM/RDM ratio and the Dickson quality index (DQI) (Figure 2). The overall means of the analyzed variables were 5.78 cm of H, 0.59 mm of SD, 41.15 $cm^2$ of LA, 0.48 g of SDM, 0.78 g of RDM, 1.24 g of TDM, 0 .59 for SDM/RDM ratio and 0.14 for DQI.

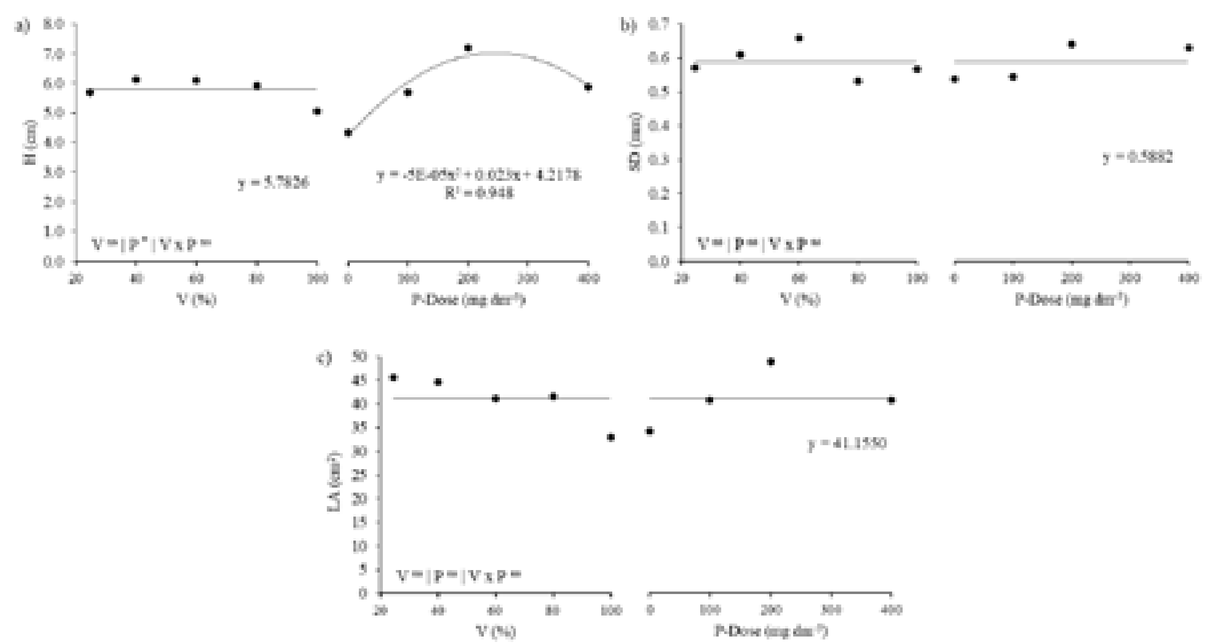


**Figure 1.** Growth of cagaiteira seedlings (*Eugenia dysenterica* DC.) as a function of liming (V%) and phosphate fertilization (P); height - H (a), stem diameter - SD (b), leaf area - LA (c).

Native plants to the Cerrado have developed adaptive mechanisms that allow their development in the adverse conditions to which they are subjected in this environment, such as water deficit, acidity, Al toxicity and low chemical fertility of their soils (Furquim *et al*., 2018). The lack of significant effect of correction of soil acidity by liming on most of the studied variables indicates the ability of cagaiteira to survive conditions that would be harmful to most cultivated plants, not responding to the increase in soil base saturation (Freitas *et al*., 2018).

Melo and Haridasan (2009) also observed that P fertilization, even at the lowest applied dose (100 mg $kg^{-1}$), contributed to the growth in height 329.7 % increase of cagaiteira seedlings. However, diverging with the results found in the present work, the authors also observed increments in cagaiteira plants supplied with Ca and P that obtained an average height 3.3 times greater than the plants without fertilization, recommending the application of at least 100 mg $kg^{-1}$ of P to obtain greater plant growth. The divergence in relation to the response to Ca not found in the current study is probably due to its initial availability in the soil (0.93 cmolc $dm^{-3}$; Table 1) which, although considered low according to interpretation criteria for the soils in the region (Alvarez et al., 1999), was sufficient for the growth of seedlings of the species, unlike the soil (0.17 $cmol_c$ $dm^{-3}$ of Ca) used in the study by Melo and Haridasan (2009).

Seedlings of gabiroba (Mello Duarte *et al*., 2021) and ipê-roxo [*Handroanthus impetiginosus* (Mart. ex DC) Mattos] (Lopes, 2022) increased in height as P doses were increased. These seedlings still showed negative quadratic effects, with an increase in the diameter of the stem and in the number of leaves with the initial increase in P doses. Baru seedlings (*Dipteryx alata*), another species native to the Cerrado, were little influenced by base saturation and phosphate fertilization, recommending an increase in base saturation to only 20%, without the need for P application (Freitas *et al*., 2018). Young plants of mountain guava (*Acca sellowiana*) showed little response to P application in the first years of cultivation. P levels had no effect on any of the evaluated variables, namely trunk perimeter, plant height and crown diameter (Nava *et al*., 2016).

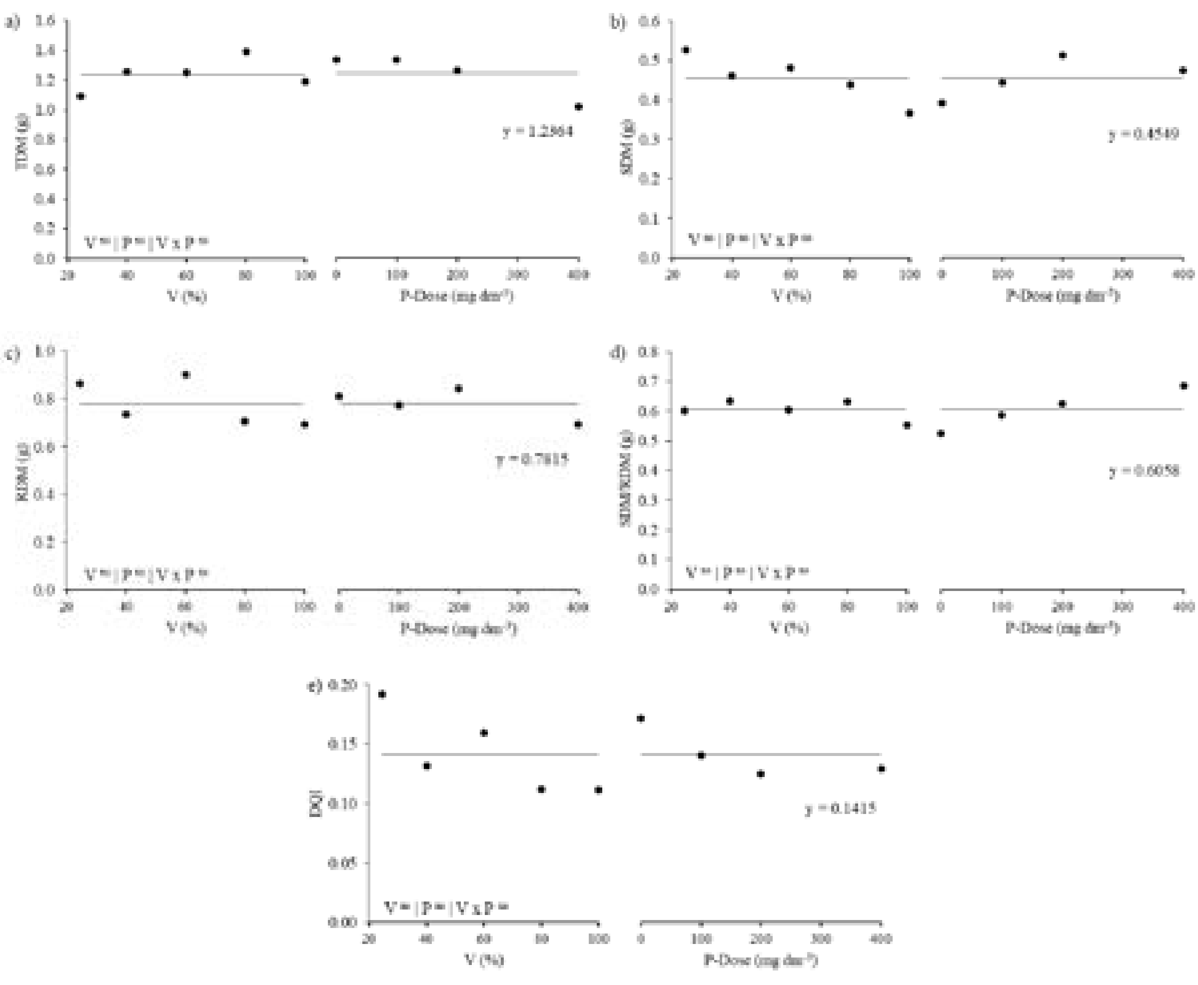


**Figure 2.** Dry matter production and Dickson Quality Index of cagaiteira seedlings (*Eugenia dysenterica* DC.) as a function of liming (V%) and phosphate fertilization (P); total dry matter - TDM (a), shoot dry matter - SDM (b), root dry matter - RDM (c), ratio RDM/SDM (d) and Dickson Quality Index - DQI (e).

In the present study, plants invested more in root production, with an average RDM/SDM ratio of 0.605. Greater growth of the root system, compared to the growth of the aerial part, of *E. dysenterica* was also observed by Sano *et al*. (1995) and by Silveira *et al*. (2013). Some native plants from Cerrado have a striking characteristic in the initial growth phase in which they direct more energy to the development of the root system, being a strategy to cross periods of drought after emergence (Bessa *et al*., 2016), as this manages to reach layers deeper in the soil.

The variance analysis for the macronutrient accumulation in the shoots (mg $PA^{-1}$) of the cagaiteira indicated that there was a significant interaction for the N content, with a higher value when neither liming nor fertilization with P was performed (Figure 3a). Lime significantly influenced the content of P and K, with higher values when the soil was not corrected; 1.12 mg of P and 2.54 mg of K (Figures 3b and 3c).

The behavior observed in the study for nitrogen (N) can be explained by the increase in soil pH due to liming (Table 2), which promotes greater nitrification, leading to higher losses of N in the soil in the form of nitrate through leaching. Additionally, higher soil pH values may favor greater conversion of ammonium to ammonia, resulting in increased N losses through volatilization (Cantarella, 2007). With such losses (leaching/volatilization), an increase in the V% leads to a decrease in nutrient availability in the soil, its absorption (Rocha, 2018), and its accumulation in plants (Fig. 3a).

Furthermore, with the increase in base saturation due to liming, especially at high limestone doses, phosphorus (P) precipitates with calcium (Ca) (Novais *et al*., 2007), thereby reducing its availability in the soil and its absorption by plants, reflected in its lower accumulation in the aerial part of the seedlings (Fig. 3b).

For potassium (K) (Fig. 3c), on the other hand, the higher concentration of calcium (Ca) in the soil, due to the increase in V% (Table 2), can promote greater leaching of K, resulting in lower absorption by seedlings (Rocha, 2018) and consequently a reduced accumulation of K in plants (Fig. 3c). Calcium and potassium compete for the same exchange sites on soil colloids, with the divalent element (Ca) exhibiting greater retention compared to the monovalent one (K) (Meurer; Rheinheimer; Bissani, 2017).

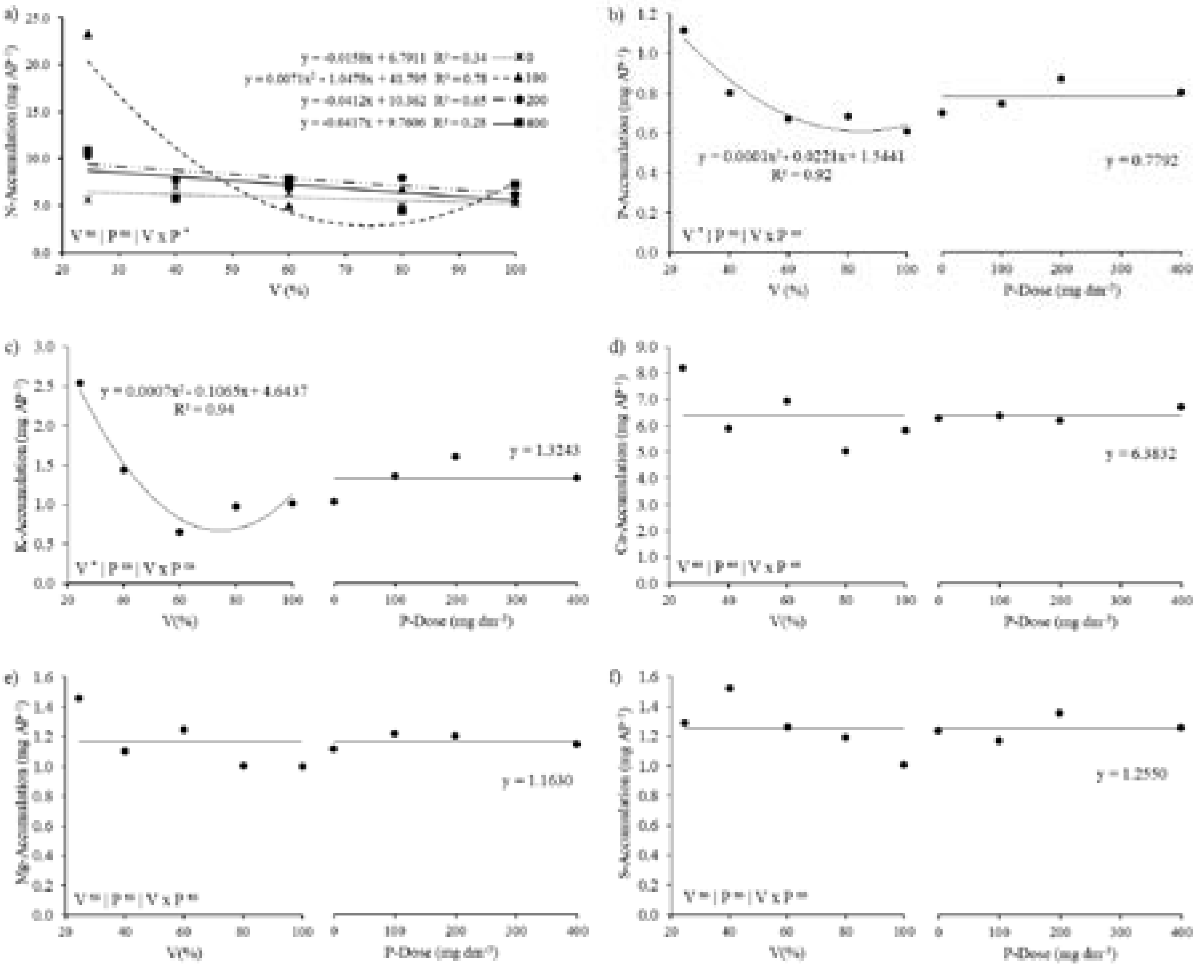


**Figure 3.** Macronutrient accumulation in the aerial part of cagaiteira seedlings (*Eugenia dysenterica* DC.) as a function of liming and phosphate fertilization; N (a), P (b), K (c), Ca (d), Mg (e) and S (f).

In general, the present study demonstrated that plants not subjected to liming had higher accumulation of some macronutrients in the shoot (Figure 3). Possibly, Cerrado species, due to the development environment, have a greater efficiency in the use of nutrients and, therefore, do not respond to the application of lime. Analyzes on the development of *Campomanesia adamantium* seedlings, a fruit tree from the Cerrado popularly known as 'guavira' or 'gabiroba', also showed that the macronutrient contents in the shoots and roots of the seedlings were higher when the plants were not subjected to liming in a substrate formed by 50% of soil (Dysferric RED LATOSOL) + 50% of sand, however, in the substrate without the addition of sand, the highest levels of nutrients were found when a dose equivalent to 5 t $ha^{-1}$ of limestone was used (Melo *et al*., 2019).

The higher availability of P did not reflect significantly in higher content of the nutrient in the aerial part of the cagaiteira of the present study, as well as not in the content of P in gabiroba (Melo *et al*., 2019). These results may be associated with a possible formation of P chelated compounds, decreasing the absorption of the nutrient by the seedlings, in addition to the natural adaptation of these plants to the conditions of the acidic soils of the Cerrado, impairing the absorption of nutrients in alkalized soils (Melo *et al*., 2019). There are reports on the ability of *Brachiaria ruziziensis* to exudate citrate or oxalate under low pH conditions (Louw-Gaume *et al*., 2010) and on sweet potatoes (*Ipomoea batatas*) to exude mainly oxalate at low P availability (Minemba *et al*., 2019). These organic acids promote the chelation of $Al^{3+}$, $Fe^{3+}$ and $Ca^{2+}$, to promote the sorption of P, increasing its availability to the plant (Gerke, 2015). Thus, it can be assumed that the cagaiteira has similar mechanisms for the use of P when its availability is very low in the soil (Table 1).

Soil pH was increased with the application of increasing doses of lime (Table 2), which may have provided less availability of nutrients, mainly in relation to metallic micronutrients and, for this reason, cagaiteira seedlings had lower Fe contents, Mn, and Zn in the shoot (Figure 4). The increase in soil pH promoted an increase in P availability, however higher soil pH values also provide lower availability of the nutrient due to its precipitation with Ca ions (Novais *et al*., 2007) and, thus, lower P content in the plants (Figure 3b). A reduction in Cu, Fe Mn, and Zn contents in the shoot of the 'umbu' tree (*Spondias tuberosa*), in a study on the effect of increased base saturation on the growth and mineral nutrition of the species, was also observed by Neves *et al*. (2015).

Additionally, the uptake of cations such as K, Cu, Fe, Mn, and Zn by plants can be reduced by competition with the cationic Ca and Mg. B becomes more available as soil pH increases to values close to 7.0 (Abreu; Lopes; Santos, 2007). Furthermore, B in the soil is mainly adsorbed by the carboxylic groups of humic acids in organic matter. With the increase in the limestone dose, the concentration of $OH^-$ ions in the soil increased and, by mass effect (concentration), these hydroxyls promoted desorption of the B retained in the clays/soil organic matter (SOM) and thus greater availability in the solution, absorption, and B content at the plants, which explains the increase in B content in the aerial part of the plants. Furthermore, with the increase in soil pH due to liming (Table 2), there is greater decomposition of SOM (greater source of B in the soil) and, therefore, greater availability of B to plants (Adriano, 1986).

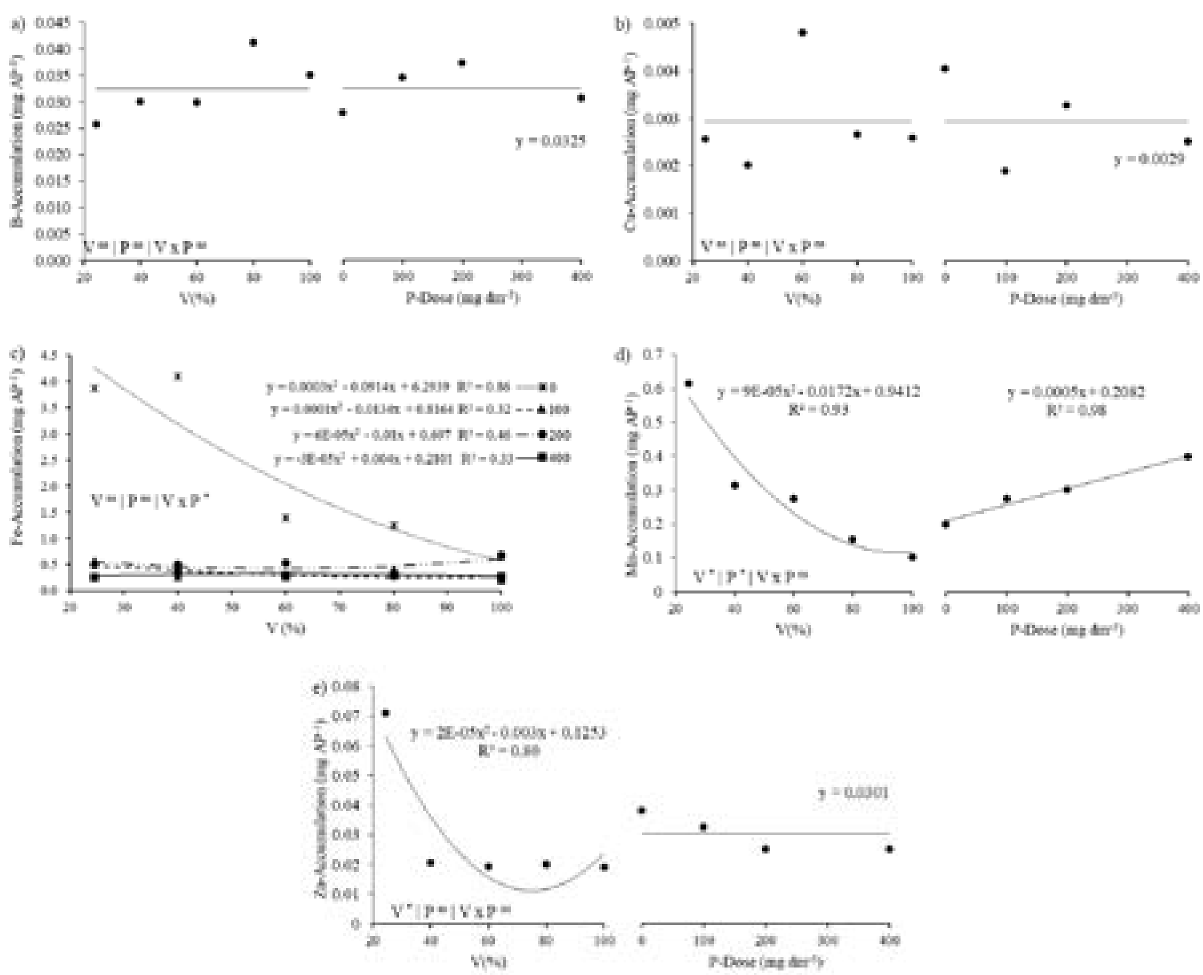


**Figure 4.** Micronutrient content accumulation in the aerial part of cagaiteira seedlings (*Eugenia dysenterica* DC.) as a function of liming and phosphate fertilization; B (a), Cu (b), Fe (c), Mn (d) and Zn (e).

The increase in base saturation and P doses did not influence the physiological responses in net photosynthesis rate (*A*), transpiration rate (*E*), stomatal conductance ($g_s$) and water use efficiency (WUE) of cagaiteira plants. The average for *A* was 8.52 μmol $m^{-2}$ $s^{-1}$, for *E* it was 1.71 mmol $m^{-2}$ $s^{-1}$, for $g_s$ it was 79.04 mmol $m^{-2}$ $s^{-1}$ and 5.37 for WUE (Figure 5).

The results were similar to those found by Mota *et al*. (2016) and Mota *et al*. (2018), who also did not identify a significant difference in gas exchange when evaluating different substrates in both studies. However, Reis *et al*. (2020) observed an increase in gas exchange with the increase of P supply for *E. dysenterica* up to 200 mg $dm^{-3}$; beyond this dose, there was a stabilization of the variables. Phosphorus availability can stimulate the production of stomata by epidermal cells, resulting in increased conductance and photosynthesis (Jacob; Lawlor, 1991).

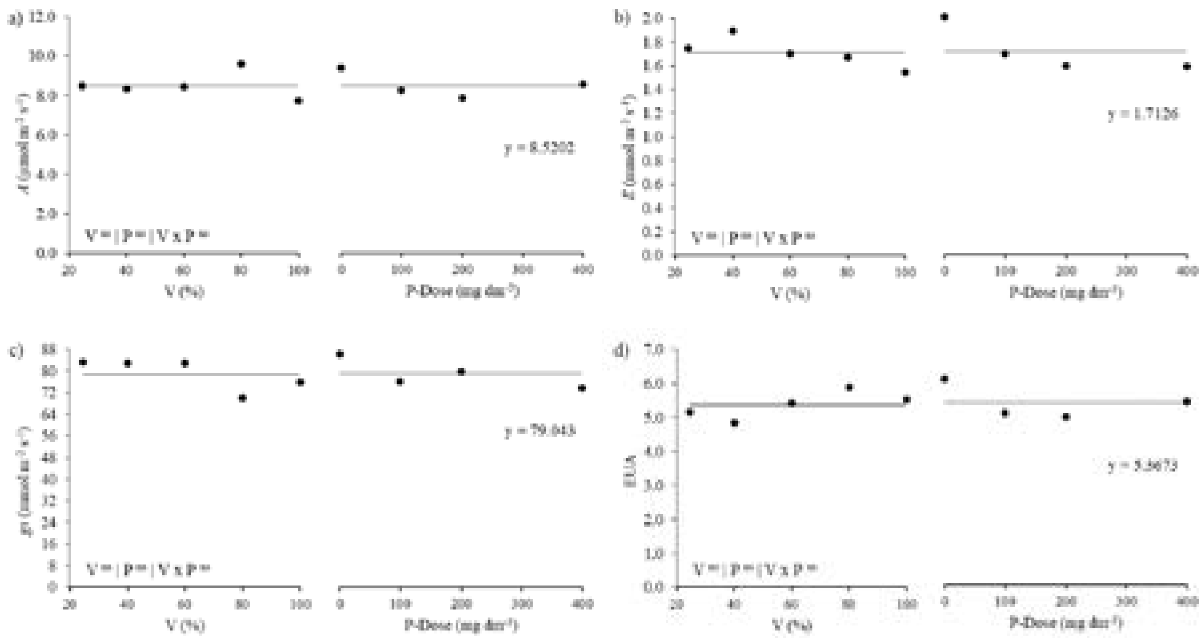

**Figure 5.** Physiological variables of cagaiteira seedlings (*Eugenia dysenterica* DC.) as a function of liming and phosphorus fertilization. *A* (a), *E* (b), $g_s$ (c) and WUE (d).

The fact that liming did not positively influence most of the variables studied indicates the cagaiteira's ability to develop in environments where conditions are considered adverse to the survival of most cultivated plants. In this context, the species presents itself as promising for use in soils with low chemical fertility, as well as in the recovery of degraded areas.

## CONCLUSIONS

The growth and physiology of *Eugenia dysenterica* DC seedlings. they are not influenced by liming; however, the application of lime positively influences the B content in the plants.

Phosphate fertilization increases growth in height, with an estimated dose of 245 mg $dm^{-3}$ of P indicated to produce cagaiteira seedlings, since at this dose, it is estimated that the plant will be taller.

In general, cagaiteira proves to be a species that develops well in acid soil conditions and with low availability of P.

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