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# Doses of limestone, phosphorus and potassium on the initial development of *Anacardium humile* seedlings

## *Doses de calcário, fósforo e potássio no desenvolvimento inicial de mudas de Anacardium humile*

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**ABSTRACT:** The objective of this work was to evaluate the effect of different doses of limestone, phosphorus, and potassium on the initial development of *Anacardium humile* (Cajuzinho-do-cerrado) seedlings. The experiment was conducted in a greenhouse. A randomized block design was adopted in a 3x4x4 factorial scheme (liming *x* phosphorus *x* potassium doses). The treatments consisted of three liming doses (0; 40; and 70% of base saturation), four doses of potassium chloride with 60% of $K_2O$ (0; 60; 120; and 180 kg $ha^{-1}$), and four doses of triple superphosphate with 46% of $P_2O_5$ (0; 80; 160; and 240 kg $ha^{-1}$), with six replications. The following characteristics were evaluated: stem diameter (SD), plant height (PH), root length (RL), shoot dry matter (SDM), and root dry matter (RDM). The data were submitted to analysis of variance and the averages were compared by Tukey's test ($p < 0.05$). It was concluded that there was no influence of phosphorus doses on the initial development of *A. humile* seedlings and that there was a response to the association between liming and potassium chloride in vegetative growth.

**Keywords:** Cerrado biome. Native fruits. Potassium chloride. Triple superphosphate. Fertilization.

**RESUMO**: O objetivo do presente trabalho foi avaliar o efeito de diferentes doses de calcário, fósforo e potássio no desenvolvimento inicial de mudas de *Anacardium humile* (Cajuzinho-do-cerrado). O experimento foi conduzido em casa de vegetação. Adotou-se o delineamento experimental em blocos casualizados em esquema fatorial 3x4x4 (doses de calcário *x* fósforo *x* potássio). Os tratamentos consistiram em três doses de calcário (0; 40; e 70% de saturação por bases), quatro doses de cloreto de potássio com 60% de $K_20$ (0; 60; 120; e 180 kg $ha^{-1}$), e quatro doses de superfosfato triplo com 46% de $P_2O_5$ (0; 80; 160; e 240 kg $ha^{-1}$), com seis repetições. Foram avaliadas as características: diâmetro do caule (DC), altura das plantas (AP), comprimento de raiz (CR), matéria seca da parte aérea (MSPA) e matéria seca da raiz (MSR). Os dados foram submetidos à análise de variância e as médias comparadas pelo teste de Tukey ($p < 0,05$). Conclui-se que não houve influência das doses de fósforo no desenvolvimento inicial das mudas de *A. humile* e que houve resposta para a associação entre a calagem e o cloreto de potássio no crescimento vegetativo.

**Palavras-chave**: Bioma cerrado. Frutas nativas. Cloreto de potássio. Superfosfato triplo. Adubação.

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## INTRODUCTION

Brazil has several native species that are still unknown and many that have great potential for commercial exploitation. Among the biomes rich in native species of commercial interest there is the Cerrado, which is the second largest biome in South America and corresponds to 22% of the Brazilian territory (MOREIRA-ARAÚJO *et al*., 2019). The Cerrado cashew (*Anacardium humile*) is one of the native species that have great potential to generate income in the Midwest region and is threatened with extinction, which is why more studies are needed (RODRIGUES *et al*., 2016; BARBOSA *et al*., 2018).

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Cerrado soils are highly weathered, which makes them soils with low fertility that limit plant growth, thus, the excess or the lack of nutrients in management of this type of soil must be avoided (MATIAS *et al*., 2019). The acidity caused by weathering is the main responsible for the decrease of nutrients in the soil, reason why many native species are tolerant of this feature, but they present restricted productivity due to this deficiency, being the soil correction by base saturation recommended. This practice considers the needs of each species and must be monitored since the seedling production phase until its introduction into the field (VIEIRA; WEBER, 2017).

One of the main elements demanded by plants is potassium, he participates in many biochemical processes and is related to carbohydrates metabolism, photosynthesis, and respiration. In plants, potassium controls the stomatal opening, resistance to pests and diseases through plasmatic membrane permeability, and increases root growth affecting plants development; it can also influence fruit quality since at proper levels can increase size, firmness, soluble solids content and the excess reduces fruit firmness and post-harvest quality (ARAÚJO *et al*., 2018; BARRETO *et al*., 2020).

Limestone increases base saturation, keeping nutrients availability at the optimal level, which is important because low fertility and nutrients availability, besides toxicity and acidity, limits plant productivity and hinders her to reach their full potential. Liming increases pH, neutralizes toxic aluminum, increases calcium and magnesium supply, improves cation exchange capacity (CEC) and exchangeable bases, and also favors root system growth, however, many native species of Cerrado do respond on different ways. (SILVA *et al*., 2019; MATIAS *et al*., 2019).

Despite being required in little amounts by the plants, phosphorus plays an important role because it is limiting for the production due to its low available values and facility of fixation to soil particles (SANTINI *et al*., 2019), he operates on processes of storage and transfer of energy, and the deficit in acid soils causes inappropriate vegetative growth since shoots and root systems are affected by its irregular growth (FREITAS *et al*., 2017). Phosphorus availability depends on soil characteristics, and the liming is a necessary practice to increase the phosphorus amount available to the plants because in acid soils its adsorption increases (SOUZA *et al*., 2018).



The species *A. humile* presents great potential, but there is a lack of studies aiming to subsidize the knowledge of its commercial exploitation or its use on breeding programs (RODRIGUES *et al*., 2016), besides, due to the deterioration that occurs in Cerrado biome caused by the expansion of agricultural borders and predatory extractivism, it is very important to seek the conservation of this species (COTA *et al*., 2017). Due to seedlings production be an important phase of crop system because it reflects on plants final performance in the field (SILVA; IGNÁCIO; SILVA, 2017), this work aimed to evaluate different doses of phosphorus, potassium, and limestone in the initial development of *A. humile* seedlings.

## 2 MATERIAL AND METHODS

The experiment was carried out in a greenhouse. The seeds of *A. humile* were collected in the municipality of Mineiros - GO from fruits of native plants in the Parque Nacional das Emas, and treated with the fungicide Mancozeb for the elimination of pathogens from the field. The sowing was carried out with three seeds in polyethylene bags with a capacity of 1.0 $dm^3$ and after germination, the seedlings were transferred to bags with capacity for 3.0 $dm^3$ keeping only one seedling per bag, in which each bag was considered an experimental unit.

The experimental design adopted was randomized blocks in a factorial scheme 3x4x4 (liming *x* potassium doses *x* phosphorus doses) in six replications with three plants, totaling 864 sampling units. The treatments used were: Three doses of limestone (PRNT = 55%) (Natural soil without adjustment of base saturation [0%], until reaching 40%

of base saturation, and until reaching 70% of base saturation); four doses of potassium chloride with 60% of $K_2O$ (0; 60; 120 and 180 kg ha$^{-1}$), and four doses of triple superphosphate with 46% of $P_2O_5$ (0; 80; 160 and 240 kg ha$^{-1}$).

The substrate used in all treatments was a Dystrophic Red Latosol collected in a Cerrado vegetation area in the municipality of Jataí - GO and passed through a 4.0 mm mesh sieve. Soil samples were collected for analysis of chemical characteristics (Table 1).

**Table 1.** Soil analysis results for chemical characteristics

| Characteristic | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Depth | pH | OM | P | $K^+$ | $Ca^{+2}$ | $Mg^{+2}$ | $Al^{+3}$ | H+Al |
| cm | $CaCl_2$ | (g dm$^{-3}$) | (mg dm$^{-3}$) | | --------------cmol$_c$ dm$^{-3}$------------- | | | |
| 0-20 | 5.4 | 23.0 | 0.5 | 10 | 1.33 | 0.28 | 0.6 | 4.1 |

Phosphorus and limestone doses were incorporated into the soil and distributed in polyethylene bags with a capacity of 3.0 dm$^3$ and potassium doses were divided into three applications with intervals of 15 days between them, the soil was prepared separately according to each treatment.

The seedlings were kept in a greenhouse for 210 days, irrigated by drip with a daily discharge of 5.55 ml per plant. Weekly applications of fungicides with Dithane NT (80% Mancozeb) were made to control anthracnose.

At the end of the experiment was evaluated the stem diameter (SD), measured at 10 centimeters from the seedling collar and expressed in millimeters; the plant height (PH), measured from the collar of the plant to the apical meristem and given in centimeters; the root length (RL), measured along the main root and given in centimeters. The plant material of the shoot was separated from the roots, dried in an oven at 62 °C by 72 hours, and weighed on a precision weighing machine to determine the shoot dry matter (SDM) and root dry matter (RDM) in grams.

The data were verified for normality, submitted to analysis of variance and tested by Tukey test at 5% significance in the statistical program SISVAR version 5.3 (FERREIRA, 2019).



## 3 RESULTS AND DISCUSSION

There was a difference between the doses of liming for the morphological characteristic root length and between the doses of potassium for the shoot dry matter of the seedlings of *A. humile*, there was also an interaction between the doses of limestone and potassium for the stem diameter (Table 2).

**Table 2.** Summary of analysis of variance for the characteristics plant height (PH), stem diameter (SD), shoot dry matter (SDM), root dry matter (RDM) and root length (RL) of *A. humile* seedlings treated with limestone doses until reach 0% (natural soil), 40 and 70% of base saturation, with 0; 80; 160 and 240 kg ha$^{-1}$ of $P_2O_5$, and with 0; 60; 120 and 180 kg ha$^{-1}$ of $K_2O$

| | | Mean square | | | | |
|---|---|---|---|---|---|---|
| **VF** | **DF** | **PH** | **SD** | **SDM** | **RDM** | **RL** |
| **BLOCK** | 5 | 80.72 | 13.98 | 12.71 | 8.13 | 89.70 |
| **LIMING** | 2 | 10.84 | 1.35 | 2.57 | 3.27 | 297.86* |
| **K** | 3 | 17.62 | 4.62 | 6.16* | 2.64 | 58.91 |
| **P** | 3 | 3.62 | 0.69 | 0.82 | 1.95 | 17.86 |
| **LIM*K** | 6 | 6.55 | 4.95* | 2.23 | 1.01 | 33.21 |
| **LIM*P** | 6 | 2.60 | 1.40 | 1.10 | 2.21 | 85.62 |
| **K*P** | 9 | 8.15 | 3.38 | 2.69 | 1.12 | 56.11 |
| **LIM*K*P** | 18 | 6.12 | 2.66 | 1.33 | 1.46 | 46.49 |
| **Residual** | 235 | 8.43 | 1.97 | 1.54 | 1.52 | 40.61 |
| **CV (%)** | | 41.18 | 22.24 | 57.82 | 41.70 | 26.24 |

* significant ($p < 0.05$).

The lack of response to liming by many of the evaluated characteristics may have occurred due to the adaptation of plants of this species to more acidic soils or perhaps due to the calcium and magnesium contents in the soil that met the initial nutritional requirement. Silva *et al*. (2019), also observed that the biometric parameters of *Hymenaea stigonocarpa* seedlings were not influenced by the increase in base saturation, indicating that the calcium and magnesium contents present in the soil and seed reserve tissues were sufficient to meet the seedling needs, which is why there is no need for liming in the production of Cerrado species seedlings since excess calcium causes toxicity and leads to a reduction in vegetative growth. Similar results were recorded for seedlings of *Astronium fraxinifolium, Guazuma ulmifolia, Anadenanthera macrocarpa* and *Inga edulis* (SILVA; PEREIRA; RODRIGUES, 2011).

High levels of potassium in the soil can generate an imbalance between magnesium levels. These elements interact with each other and for the application of high doses of potassium, it is necessary adequate amounts of magnesium, which is a possible reason why there was a significant interaction between the doses of potassium and the liming, the main source of the element magnesium (SILVA *et al*., 2008).

Similar results for phosphorus application, in which there was no response, were reported by Lima *et al*. (1997), and Santos et al. (2008), for native forest species. The lack of response to phosphorus application for the biometric parameters of *A. humile* seedlings may have occurred due to the fact that the contents used in the present study were inadequate for the crop, as observed by Santini *et al*. (2019), for the soybean in Cerrado soils.

Under the Cerrado conditions, the soils usually present low phosphorus content, because they have high adsorption capacity, especially in the presence of iron and aluminum, which is why phosphorous fertilization should be supplied at higher levels than those demanded by the crop, in addition, the more acid the soil is the greater the adsorption of the element, causing the availability of phosphorus in latosols to be reduced (SOUZA *et al*., 2018).



The shoot dry matter of the seedlings treated with potassium fertilizer differed between the doses evaluated, in which the doses of 0 and 60 kg ha$^{-1}$ showed an increase in this characteristic, in addition, the dose of 120 kg ha$^{-1}$ did not differ from the lower doses (Table 3).

**Table 3.** Shoot dry matter (SDM) of *A. humile* seedlings in potassium doses of 0; 60; 120 and 180 kg ha$^{-1}$ of $K_2O$

| Dose (kg ha$^{-1}$) | SDM (g) |
|---|---|
| **0** | 2.41 A |
| **60** | 2.37 A |
| **120** | 1.99 AB |
| **180** | 1.81 B |

Means followed by different letters differ by Tukey's test ($p < 0.05$).

When the doses of potassium applied are higher than the nutritional demands of the crop, an antagonistic effect may occur in plants, a similar behavior was observed by Araújo *et al*. (2018), in which the increase in potassium dose led to a decrease in the fresh weight of common cashew seedlings (*A. occidentale*).

The in base saturation to 40 and 70% reduced root system development (Table 4). This indicates that perhaps the studied species do not respond to soil pH correction since it is adapted to the Cerrado soils, whose main characteristic is soils with high levels of exchangeable aluminum. Many species of this biome develop adaptive mechanisms to acidic soils, such as species that decrease aluminum absorption by increasing the pH of the rhizosphere or excluding the element from plant tissues, developing tolerance to aluminum toxicity (FREITAS *et al*., 2017).

**Table 4.** Root length (RL) of *A. humile* seedlings with doses of liming until reaching saturation of bases of 0%, 40% and 70%

| Base saturation (%) | RL (cm) |
|---|---|
| **0** | 26.19 A |
| **40** | 23.97 B |
| **70** | 22.71 B |

Means followed by different letters differ by Tukey's test ($p < 0.05$).

There was significant interaction for the stem diameter of *A. humile* seedlings between the limestone doses and 60 kg ha$^{-1}$ of potassium; between potassium and limestone doses until they reach 40% of base saturation, and between potassium and limestone doses until they reach 70% of base saturation (Table 5).

**Table 5.** Summary of analysis of variance for the interactions between liming (0; 40 and 70% of base saturation) and potassium doses (0; 60; 120 and 180 kg ha$^{-1}$ of $K_2O$) for stem diameter (SD) of *A. humile* seedlings

| VF | DF | SQ | MS | Fc |
|---|---|---|---|---|
| **Liming / 0 kg ha$^{-1}$ of $K_2O$** | 2 | 11.91 | 5.95 | 3.03 |
| **Liming / 60 kg ha$^{-1}$ of $K_2O$** | 2 | 12.55 | 6.27 | 3.19* |
| **Liming / 120 kg ha$^{-1}$ of $K_2O$** | 2 | 6.53 | 3.27 | 1.66 |
| **Liming / 180 kg ha$^{-1}$ of $K_2O$** | 2 | 1.45 | 0.73 | 0.37 |
| **$K_2O$ / 0% of base saturation** | 3 | 5.82 | 1.94 | 0.99 |
| **$K_2O$ / 40% of base saturation** | 3 | 16.73 | 5.58 | 2.84* |
| **$K_2O$ / 70% of base saturation** | 3 | 21.04 | 7.01 | 3.57* |
| **Residual** | 235 | 462.26 | 1.97 | |



* significant ($p < 0.05$).

The stem diameter is related to shoot and root system growth and favors the survival and development of seedlings after planting, which is why this characteristic is an indicator of quality in the seedling production system (SILVA; IGNÁCIO; SILVA, 2017). According to Silva *et al.* (2019), the increase in base saturation up to 70% results in an increase in the translocation of nutrients to the stem and leaves.

The stem diameter was higher at doses of 60 kg ha$^{-1}$ of potassium associated with liming until reaching 70% base saturation and without the addition of potassium (0 kg ha$^{-1}$) associated with liming until reaching base saturation of 40% (Table 6). There must be a balance between potassium, calcium, and magnesium, because root absorption of monovalent cations, as $K^+$ is faster than absorption of bivalent cations, such as $Ca^{2+}$ and $Mg^{2+}$, this generates competition between them and causes the uptake of calcium and magnesium to be reduced, and to achieve maximum absorption it is necessary that there is a balance between them (MONTES *et al.*, 2016).

**Table 6.** Stem diameter (mm) for the dose of 60 kg ha$^{-1}$ of $K_2O$ combined with liming (0; 40 and 70% of base saturation [BS]) and for potassium doses (0; 60; 120 and 180 kg ha$^{-1}$) combined with liming until reaching 40 and 70% of base saturation of *A. humile* seedlings

| | 60 kg ha$^{-1}$ of $K_2O$ | | 40% BS | 70% BS |
|---|---|---|---|---|
| **0% BS** | 6.68 AB | **0 kg ha$^{-1}$ of $K_2O$** | 6.72 A | 5.83 B |
| **40% BS** | 6.05 B | **60 kg ha$^{-1}$ of $K_2O$** | 6.05 AB | 7.07 A |
| **70% BS** | 7.07 A | **120 kg ha$^{-1}$ of $K_2O$** | 5.59 B | 6.28 AB |
| | | **180 kg ha$^{-1}$ of $K_2O$** | 6.39 AB | 6.05 AB |

Means followed by different letters differ by Tukey's test ($p < 0.05$).

Liming provides an indirect effect on potassium, discharging the connections made in the soil by aluminum and used by the elements $Ca^{2+}$, $Mg^{2+}$ and $K^+$, that is, increasing the cation exchange capacity of the soil and benefiting the absorption by plants. However, an antagonistic effect may occur, since plasmatic membrane absorption sites are usually shared among other cations, and there may be competition in which increased concentration of one element decreases the availability of the other (ERNANI; ALMEIDA; SANTOS, 2007).

Cations such as potassium can cross the plasma membrane faster, impairing the absorption of slow cations such as Ca and Mg, which creates deficiencies and compromises growth and productivity. The use of high doses of potassium chloride can cause toxicity in plants (MARSCHNER, 2012; MIYAKE *et al*., 2016).

## 4 CONCLUSIONS

The doses of phosphorus applied did not influence the development of *A. humile* seedlings. The plants responded to the application of KCl associated with the adjustment in base saturation through the liming, promoting an increase in growth.

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