Brazilian Journal of Biology®

ISSN 1519-6984 (Print)
ISSN 1678-4375 (Online)

Original Article

# Growth and production of cowpea beans under potassium doses in soil of cerrado in Amapá, Brazil

## Crescimento e produção de feijão caupi sob doses de potássio em solo de cerrado no Amapá, Brasil

K. S. Q. Costa[a], C. F. Oliveira[a], M. P. Melo[a], H. C. Lima[a], R. L. C. Ferreira[a]*, N. C. Melo[a], F. K. C. Moraes[a], F. J. R. Cruz[b], L. C. Souza[c] and V. R. Nascimento[d]

[a]Instituto Federal de Educação, Ciência e Tecnologia do Amapá, Campus Agrícola Porto Grande, Amapá - Brasil
[b]Instituto Federal de Educação, Ciência e Tecnologia do Amapá, Campus Laranjal do Jari, Amapá - Brasil
[c]Universidade Federal do Maranhão, Centro de Agricultura e Ciências Ambientais, Campus Chapadinha, Maranhão - Brasil.
[d]Universidade Federal do Pará, Instituto de Ciências Biológicas, Campus Belém, Pará - Brasil

**Abstract**

The cowpea bean [*Vigna unguiculata* (L.) Walp.], a legume of great socioeconomic importance, it was previously cultivated exclusively for subsistence and commercial purposes, especially in the North and Northeast regions. This crop has a low production cost and high nutritional value, in addition to a high potential for productivity growth and expansion to other regions. The objective of this work was to evaluate parameters of growth and production in cowpea culture, as a function of potassium fertilization in soil of the cerrado of Amapá. The parameters of growth and production of the cowpea culture were evaluated, as a function of potassium fertilization in the soil of the cerrado of Amapá. The experiment was conducted in a greenhouse, using a completely randomized experimental design, with four replications, in a 5x2 factorial scheme, totaling 40 experimental units, which were composed of plastic pots containing 7 $dm^3$ of soil collected from the arable layer (0-20 cm ) of a typical Hyperdystrophic Yellow Argisol, with a sandy clay loam texture, in a cerrado area in the municipality of Porto Grande-AP. The factors consisted of the control treatment (without K), four doses of K (45, 90, 135 and 180 kg $ha^{-1}$) in the form of potassium chloride, and two cowpea cultivars (Pretinho and BRS Tumucumaque). The cultivar BRS Tumucumaque shows better growth and production of cowpea plants. Doses of 90 kg $ha^{-1}$ provided greater height (98.75 cm) and stem diameter (10.0 mm). As for production, the dose of 135 kg $ha^{-1}$ caused greater grain weight gain (5.25 g) and dry mass of pods (13.92 g), and the doses of 90 and 180 kg $ha^{-1}$ induced greater number and length of pods (3.16 pods) respectively. These results show better responsiveness of the BRS Tumucumaque cultivar at doses of 90, 135 and 180 kg $ha^{-1}$ in the type of soil where the study was conducted.

**Keywords:** potassium fertilization, *vigna unguiculata*, legume, brs-tumucumaque and cultivar pretinho.

**Resumo**

O feijão-caupi [*Vigna unguiculata* (L.) Walp.], leguminosa de grande importância socioeconômica, era anteriormente cultivado exclusivamente para fins de subsistência e comerciais, principalmente nas regiões Norte e Nordeste. Essa cultura apresenta baixo custo de produção e alto valor nutritivo, além de alto potencial de crescimento de produtividade e expansão para outras regiões. Apesar da importância fisiológica do potássio para o crescimento das plantas e o plantio da cultura ocorrer predominantemente em solos arenosos e argilosos, há poucos estudos relacionando seu cultivo à adubação potássica. O objetivo deste trabalho foi avaliar parâmetros de crescimento e produção na cultura do feijão-caupi, em função da adubação potássica em solo do cerrado do Amapá. Foram avaliadas a altura das plantas, o diâmetro do caule, a massa seca da parte aérea (folha e caule) e da raiz e a produção (massa seca de grãos e vagens, comprimento de vagens e número de vagens) na cultura do feijão-caupi em função da adubação potássica no solo do Cerrado. do Amapá. O experimento foi controlado em casa de vegetação, utilizando delineamento experimental inteiramente casualizado, com quatro repetições, em esquema fatorial 5x2, totalizando 40 unidades experimentais, as quais foram compostas por vasos plásticos contendo 7 dm3 de solo coletado da camada arável (0-20 cm) de um típico Argissolo Amarelo Hiperdistrófico, com textura franco-argilosa arenosa. Os fatores foram constituintes do tratamento controle (sem K), quatro doses de K (45, 90, 135 e 180 kg ha-1) na forma de potássio potássico e duas cultivares de feijão-caupi (Pretinho e BRS Tumucumaque). A cultivar BRS Tumucumaque apresentou melhor crescimento e produção. A dose de 90 kg ha-1 proporcionou maior altura (98,75 cm) e diâmetro do caule (10,0 mm). Quanto à produção, a dose de 135 kg ha-1 proporcionou maior ganho de peso de grãos (5,25 g) e massa seca de vagens (13,92 g), e doses de 90 e 180 kg ha-1 induziram maior número e comprimento de vaginas (3,16 vaginas), respectivamente. Esses resultados mostram melhor responsividade da cultivar BRS Tumucumaque nas doses de 90, 135 e 180 kg ha-1 no tipo de solo onde o estudo foi realizado.

**Palavras-chave:** adubação potássica, vigna unguiculata, leguminosa, BRS-tumucumaque e cultivar pretinho.

*e-mail: raphael.ferreira@ifap.edu.br
Received: April 10, 2023 – Accepted: August 22, 2023

## 1. Introduction

Cowpea [*Vigna unguiculata* (L.) Walp.] is a legume cultivated in the North and Northeast regions of Brazil for subsistence and trade purposes, with potential for productivity growth (Cravo et al., 2006). About twelve years ago, cowpea production is expanding to the Midwest region of Brazil, based on genetic improvement, the crop that was mostly planted by family farmers has recently been inserted as the main crop or in succession to the cultivation of soybeans, corn and rice in intensive agriculture (Freire Filho et al., 2011).

The cultivation of cowpea is of great socioeconomic importance, due to its adaptability to different climatic and soil conditions (Dantas et al., 2002), low production cost and high nutritional value. This legume constitutes an excellent source of proteins and carbohydrates, therefore, it participates in the diet of urban and rural populations in the North and Northeast regions (Oliveira et al., 2009). However, despite all its benefits, cowpea has low productivity of grains at the national level (491 kg $ha^{-1}$) (CONAB, 2022), due to the use of traditional cultivars with low agronomic aptitude.

In addiction, lack of recommendations for adequate mineral fertilization to meet the nutritional needs of the crop (Oliveira et al., 2001) is another factor that contributes to the reduced production of potassium in this particular crop, as farmers may be underestimating the doses applied of this nutrient in the soil, given its great importance in the physiology of plants.

From a nutritional and physiological point of view, potassium is an essential macronutrient in plant nutrition at low levels in the form available in very weathered tropical soils (Dechen and Nachtigall, 2007). This nutrient participates in several functions in the plant, acting in the activation of enzymes that participate in the processes of photosynthesis and respiration, in the synthesis of proteins and carbohydrates, in osmotic regulation and in the translocation of nutrients (Ernani et al., 2007).

Potassium has high mobility in plants and high concentrations in the leaf tissue of cowpea, being the nutrient most extracted and exported by the crop, this fact, together with the high degree of weathering of tropical soils, justify the low levels of this nutrient in soils where the crop is commercially exploited (Melo and Cardoso, 2017). In addition, K has a great influence on the productivity of crops, through the increase in weight and quality of grains (Dechen and Nachtigall, 2007).

In the cerrado of Amapa, among the dominant soil classes mapped is the Hyperdystrophic Yellow Argisol (3.47%), which has undesirable chemical properties (Valente et al., 2015). The hot and humid climate favors the intense leaching of silica and basic cations ($Ca_2^+$, $Mg_2^+$, $K^+$), resulting in low base saturation, high aluminum saturation and high acidity (Mélem Júnior et al., 2008), however these soils have good agricultural aptitude, due to its physical properties and flat topography, which facilitate mechanized preparation combined with conservationist practices.

In this context, it is necessary to study the growth and production of the cowpea crop as a function of potassium fertilization in the cerrado of Amapa, with the aim of directing fertilizer recommendations that meet the nutritional needs of cowpea plants in the region. Thus, the objective of this work was to evaluate growth and production parameters in the cowpea crop, as a function of potassium fertilization in the soil of the cerrado of Amapá.

## 2. Material and Methods

The experiment was conducted in a greenhouse, located at the experimental farm of the Instituto Federal do Amapá (IFAP), Campus Agrícola Porto Grande (0°41’49.91’’N; 51°23’29’’E), from September/2020 to June/2021, in a typical Hyperdystrophic Yellow Argisol, with sandy loam-clay texture (Santos et al., 2018) from the cerrado area of the municipality of Porto Grande, using two cowpea cultivars and plastic pots containing 7 $dm^3$ of soil collected from the arable layer (Santos et al., 2013).

The collected soil was air-dried, crushed, homogenized and passed through stainless steel sieves with a 2 mm opening, a composite soil sample being taken and sent to the Soil Laboratory of Embrapa Amapá, for subsequent granulometric characterization according to Claessen (1997) . and chemistry according to Brasil et al. (2020). The results of the chemical and granulometric analysis are described in Tables 1 and 2, respectively.

**Table 1.** Soil chemical analysis, at depth 0-20 cm, experimental area IFAP/Campus Agrícola Porto Grande, Amapá, Brazil.

| Depth | pH | OM | P | K | Ca+Mg | Ca | Al | H+Al | [a]SB | [b]CEC (pH7) | [c]v | [d]m |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| - | $H_2O$ | g/Kg | mg/dm³ | | | | $cmol_g$ /dm³ | | | | % | |
| 0-20 | 4.0 | 12.1 | 6 | 0.02 | 0.2 | - | 0.7 | 3.1 | 0.2 | 3.3 | 6 | 78 |

[a]SB (Sum of bases); [b]CEC (Cation exchange capacity), [c]v (Base saturation) and [d]m (Aluminum saturation).

**Table 2.** Soil granulometric analysis, at depth 0-20 cm, experimental area IFAP/Campus Agrícola Porto Grande, Amapá, Brazil.

| Depth | Clay | Coarse sand | Thin sand | silt | Textural classification |
|---|---|---|---|---|---|
| - | | | g/kg | | BSSS |
| 0-20 | 229 | 420 | 190 | 161 | Sandy clay loam |

*Brazilian Soil Science Society

The design used was completely randomized (DIC), with four replications, in a 5x2 factorial scheme, corresponding to the control treatment (without K), four doses of potassium (45, 90, 135 and 180 mg $kg^{-1}$ of K) in the form of potassium chloride (KCl), and two cowpea cultivars (BRS-Tumucumaque and Pretinho), totaling forty experimental units. Based on the results of the chemical analysis of the soil, the soil acidity was corrected using 8g of vase dolomitic limestone, packed in plastic bags for incubation and corrective reaction, for 30 days.

After the corrective incubation period, the BRS-Tumucumaque and Pretinho cultivars were sown, placing ten seeds per pot. Base fertilization was carried out, with macronutrients and micronutrients, totaling 0.16 g $dm^{-3}$ of N and 1.56 g $dm^{-3}$ of P applied via soil in the form of urea and simple superphosphate and 0.30 g $dm^{-3}$ of FTE BR 12, according to the recommendation proposed by Brasil et al. (2020).

Eleven days after seedling emergence, thinning was performed, keeping two plants per pot, followed by the application of treatments (206, 530, 790 and 1050 mg $pot^{-1}$), corresponding to 45, 90, 135 and 180 kg $ha^{-1}$ of potassium chloride (KCl). Throughout the experiment, soil moisture was maintained at 60% of the total pore volume through daily watering. At 70 days after sowing, plant height and stem diameter were evaluated with the aid of a tape measure and a digital caliper, respectively. After this procedure, the plants were separated into shoots (leaf and stem) and roots for drying the plant material in an oven with forced air ventilation at 60 °C for 48 hours. The shoot and root dry matter mass were determined using an analytical balance, with units expressed in g per plant. The pod length was determined with a digital caliper and the pod mass was determined by weighing the pods on a precision analytical scale.

The results were submitted to analysis of variance by F test and, when significant differences were found between treatments, means were compared by Student's T test ($p<0.05$) for different cultivars, and the effect of potassium doses per regression analysis. The choice of polynomial regression models was based on the significance of the treatments attested by the F test and the best fit to the response variable, by the coefficient of determination ($R^2$). For statistical analyses, the Sisvar statistical package was used.

## 3. Results and Discussion

According to the analysis of variance, there was no significant interaction between potassium doses and cultivars. Potassium doses were significant for the variables height ($p<0.05$), leaf dry matter (LDM), shoot dry matter (SDM) ($p<0.01$) and pod dry matter (PDM) ($p<0.05$), however there were no significant responses for stem diameter (SD), stem dry matter (SDM), root dry matter (RDM), pod number (PN), pod length (PL) and grain weight (GW) (Table 3).

In relation to the cultivars, the variables height, stem diameter (ST), shoot dry matter (SDM) ($p<0.01$), leaf dry matter (LDM) ($p<0.05$), dry matter of root (DMR) ($p<0.01$) and pod dry matter (PDM) ($p<0.01$) were significant. On the other hand, stem dry matter (SDM), pod number (PN), pod length (PL) and grain weight (GW) were not significant.

The relationship between the application of potassium doses and plant height was positive, presenting a quadratic behavior, obtaining a maximum growth point (111.03 cm) with 90 mg $kg^{-1}$ of K. Above this potassium dose, a decrease in the growth of cowpea cultivars was observed (Figure 1). Potassium is essential for plant growth, since the deficiency of this element reduces the photosynthesis process and increases respiration, causing a reduction in the accumulation of carbohydrates, thus compromising plant growth (Dechen and Nachtigall, 2007). The increase in plant height induced by K is linked to physiological functions in plants, because it is a nutrient functionally

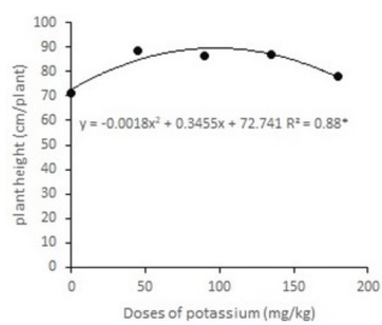


**Figure 1.** Plant height (cm/plant) as a function of doses of potassium (mg/kg). *Significant at 95% probability.

**Table 3.** Analysis of variance for plant height, stem diameter (ST), leaf dry matter (LDM), stem dry matter (SDM) and shoot dry matter (SHDM), dry matter of root (DMR), pod dry matter (PDM), number of pods (NP), pod length and grain weight (GW) of cowpea cultivars as a function of potassium (K) doses.

| Source of variation | D.L | Mean Square | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Height | ST | LDM | SDM | SHDM | RDM | PDM | NP | PL | GW |
| Doses of Potassium (K) | 4 | 437.50* | 2.50$^{ns}$ | 7.84** | 9.57$^{ns}$ | 34.34** | 0.28$^{ns}$ | 15.47* | 1.04$^{ns}$ | 13.52$^{ns}$ | 6.33$^{ns}$ |
| Cultivars (C) | 1 | 3,635.12** | 116.51** | 21.30* | 10.22$^{ns}$ | 61.08** | 7.14** | 36.13** | 1.47$^{ns}$ | 11.24$^{ns}$ | 1.33$^{ns}$ |
| K x C | 4 | 42.51$^{ns}$ | 0.44$^{ns}$ | 1.44$^{ns}$ | 2.98$^{ns}$ | 7.02$^{ns}$ | 0.68$^{ns}$ | 4.56$^{ns}$ | 0.67$^{ns}$ | 5.43$^{ns}$ | 1.15$^{ns}$ |
| CV (%) | - | 14.61 | 13.26 | 12.38 | 15.79 | 10.82 | 8.01 | 18.64 | 31.79 | 16.97 | 36.71 |

CV (coefficient of variation); D.L. (Degrees of liberty); ns (not significant); *significant (p<0,05); **significant (p<0,01) by Tukey test for doses, and Student's t test for cultivars; ST (stem diameter), LDM (leaf dry matter), SDM (stem dry matter), SHDM (shoot dry matter), RDM (root dry matter), PDM (pod dry matter), NP (number of pods), pod length (PL) and GW (grain weight).

associated with cell expansion as it has osmotic properties that induce the entry of water into plant cells (Marschner, 1995), increasing cell turgor and, consequently, growth in height. However, above 90 kg ha-1, a reduction in plant height is observed, presumably due to the high saline index (115) of potassium chloride, which in excess can salinize the plant growth substrate. In work carried out in a greenhouse with humic aluminoferric Red Latosol, there was also a significant difference in cowpea growth as a function of the potassium dose 40 days after emergence, presented an overall average below the others, corroborating that doses above the recommended are harmful to plant growth (Galeazzi, 2016).

For leaf dry matter (LDM), potassium fertilization had a positive influence, showing a quadratic behavior, with an increase (13.02 g/plant) up to the dose of 100 mg $kg^{-1}$ of K, and a reduction starting from this dose (Figure 2). This decrease is associated with excess potassium that can cause a reduction in growth and production in the plant, due to ionic and osmotic (Ernani et al., 2007). In addiction, induce the deficiency of other essential nutrients, such as magnesium induzing nutritional disorder in plants (Malavolta, 2006).

Compared to the results found in this study, potassium fertilization shows different results regarding the growth and production of crops, which show specific responses regarding soil, fertilizer management and plant species. For example, in a study of the use of coffee waste compared to conventional potassium fertilization in the development of cowpea, the authors found no difference in LDM for any of the analyzed factors (Lima, 2014). Unlike the experiment that evaluated the effects of potassium fertilization on the production and quality of soybean seeds, in which the concentration of K in the leaf increased linearly with fertilization in the first harvest, ranging from 20.53 to 22.88 g $kg^1$, in the interval between doses of 0 and 160 kg $ha^1$ of $K_2O$ (Batistella Filho et al., 2013). Also in management systems and residual effect of potassium on the productivity and nutrition of cowpea, the KCl doses significantly influenced the levels of K in the leaves, with the dose of 215.6 $kg^{-1}$ of KCl providing the highest content of K in cowpea leaves (Galvão et al., 2013).

The shoot dry mass (SHDM) was significant under potassium fertilization. It showed a quadratic behavior in which the addition of up to 138 mg $kg^{-1}$ of K provided maximum SHDM production (28.03 g/plant) (Figure 3). Potassium acts on nitrogen metabolism and protein synthesis, in addition to the control, regulation and absorption of various nutrients. Potassium is considered the most mobile element in the plant, in the dry matter of plants the levels of this nutrient vary between 6 and 50 g $kg^{-1}$ (Dechen and Nachtigall, 2007). Gains in growth require the input of photoassimilates in the growing organs via the phloem and K is associated with the carrying of sucrose in the phloem to the draining organs (Tränkner et al., 2018). Thus, it is suggested that the supply of K via fertilizer has improved the influx of sucrose to the shoot organs, increasing their growth. Results similar to those found in this study were observed by Viana and Kiehl (2010), who valuated the effect of the combination of nitrogen and potassium doses on the growth of the wheat crop, in which it was observed with the polynomial regression analysis, that the maximum production of SHDM was obtained with the combination of the dose of 251 mg $dm^{-3}$ of nitrogen with the highest dose of 200 mg $dm^{-3}$ potassium. Furthermore, it was observed that the accumulation of K in the shoots did not interact with the application of nitrogen, increasing from 50.6 to 365 mg/six plants with the supply of potassium fertilization.

Regarding the cultivar factor, the height of the plants differed statistically, with the height of the BRS-Tumucumaque (91.85 cm) greater than the height of the cultivar Pretinho (72.78 cm) (Figure 4). Although the

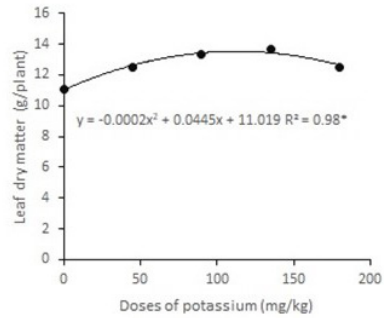


**Figure 2.** Leaf dry matter (g/plant) as a function of potassium doses (mg/kg). *Significant at 95% probability.

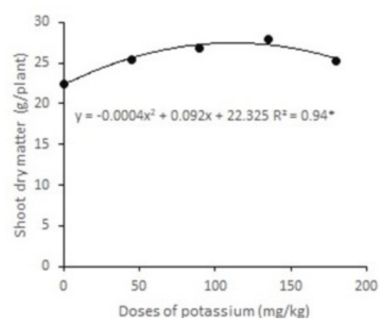


**Figure 3.** Shoot dry matter (g/plant) as a function of potassium doses (mg/kg). *Significant at 95% probability.

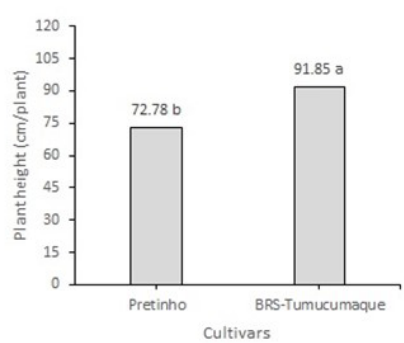


**Figure 4.** Plant height (cm/plant) according to cowpea cultivars. Different letters denote statistical differences at 95% probability.

interaction between cultivar and potassium doses was not significant, the cultivar Pretinho presented higher height in response to the dose of 45 and 90 mg $kg^{-1}$ of K. However, it is suggested that the height of the cowpea Varies According to the cultivar as evidenced by the absence of significant differences between K doses in relation to plant height. Thus, it is suggested that there is genetic diversity of cowpea cultivars used in this study in relation to height in response to potassium fertilization. In a study with genetic divergence between common bean cultivars, there was a group with higher means ($p<0.01$) composed of five cultivars, where means ranged from 75.8 to 64.4 cm (Tavares et al., 2018). However, Santos et al. (2017) in an experiment with three cowpea cultivars did not observed significant differences between the cultivars evaluated for the height variable.

As for the diameter of the stem, there were differences between the cowpea cultivars with the BRS-Tumucumaque cultivar presenting a higher average (9.39 mm) than that presented by the Pretinho cultivar (5.97 mm) (Figure 5). Similarly to the results found for height, the stem diameter seems to have a genetic response to potassium fertilization, having the highest effect at 90 mg $kg^{-1}$. This characteristic is important because the cultivar BRS-Tumucumaque has semi-erect size, suggesting a more rigid stem to avoid lodging due to the mechanical action of the wind as occurs in field condition. In a study with common bean cultivars, genotypic differences were found for stem diameter, in which a group of nine cultivars had the highest average, ranging from 6.42 to 5.72 mm (Tavares et al., 2018). Plants with larger stem diameter generally have higher production, in addition to being less susceptible to lodging and tipping over (Souza et al., 2006).

In a study on the effect of phosphate and potassium fertilization on the height and diameter of the cassava stem, there was an isolated effect of the potassium doses on the stem diameter, in which the dose of 90 kg $ha^{-1}$ of K provided a greater increase in the diameter of the stem of the plants. The authors reinforce the relevance of this result, since this variable is considered a very important parameter for the choice of seed cuttings used in planting (Souza et al., 2018).

For the leaf dry matter (LDM) variable, there was a statistical difference in relation to the cultivars, in which BRS-Tumucumaque presented a higher mean than Pretinho, with means of 13.35 and 11.89 g/plant, respectively (Figure 6). The increase in leaf area induced by potassium fertilization in this study may be associated with the role of this nutrient in plants and the contribution of K via fertilization, because it modulates the transport of enzymes involved in the transport of expansive enzymes, involved in cell expansion. In addition, potassium allows the loosening of the fibers that form the cell wall, facilitating its expansion (Oosterhuis et al., 2014; Zhou et al., 2015; Daniel et al., 2016). Likewise, Bastos et al. (2020) observed in a study with lima bean cultivars that the cultivar factor was significant ($p<0.05$) for LDM, obtaining better performance with the miraculous cultivar.

In a study on different levels of NPK fertilization, the growth of common bean cultivars showed genotypic differences, with the IAC Alvorada cultivar having a higher LDM than the Pérola cultivar. In addition, foliar K contents in all treatments were above the range of 20 to 24 g $kg^{-1}$, due to the average content of this nutrient in the soil: 3.0 mmol c $dm^{-3}$ (Santos et al., 2015).

The variable shoot dry matter (SHDM) differed statistically between the evaluated cultivars, where BRS-Tumucumaque (26.84 g/plant) showed a greater increase in SHDM compared to cultivar Pretinho (24.37 g/plant) (Figure 7). The results of the present study differ

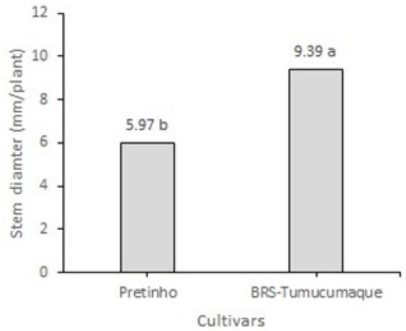


**Figure 5.** Stem diameter (mm) according to cowpea cultivars. Different letters denote statistical differences at 95% probability.

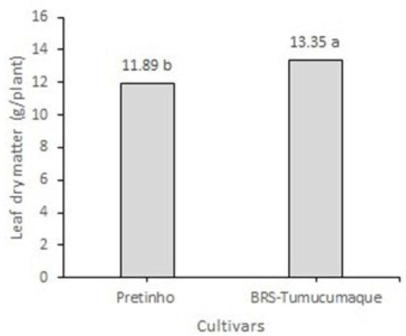


**Figure 6.** Leaf dry matter (g/plant) according to cowpea cultivars. Different letters denote statistical differences at 95% probability.

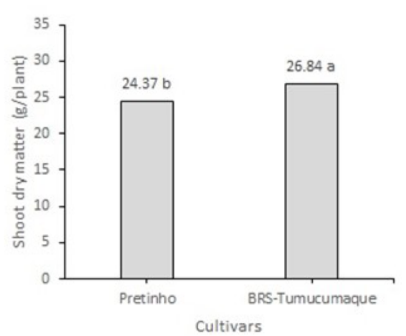


**Figure 7.** Shoot dry matter (g/plant) according to cowpea cultivars. Different letters denote statistical differences at 95% probability.

from the study conducted by Galvão et al. (2013), who, when evaluating the residual effect of potassium on the productivity and nutrition of three cowpea cultivars, observed that the SHDM and cultivars relationship was not significant. The authors point out that even with an increase in K concentrations in the soil, the content of the element found in the SHDM of the cultivars is still considered low, and may be related to the genetic variability, which promotes the development of cultivars at low doses of KCl. Root dry matter (RDM) had a greater increase (p<0.01) with the BRS-Tumucumaque cultivar (10.17 g/plant) when compared to the Pretinho cultivar (9.32 g/plant) (Figure 8). In an experiment evaluating grain yield and nodulation in cowpea cultivars, significant effects (p<0.01) also occurred for RDM, where BRS Imponente (0.789 g) and BRS Itaim (0.798 g) cultivars produced greater volume of roots, while BRS Tumucumaque had the fifth highest average (0.448 g) for RDM among the eleven evaluated cultivars, reiterating the presence of variety among the cultivars (Menezes et al., 2019). The shoots and roots of BRS-Tumucumaque plants showed higher dry mass accumulation in response to potassium fertilization. However, the shoot dry mass (26.84 g plant-1) was 2.6 times greater than the root dry mass (10.17 g plant-1). These results suggest that potassium fertilization favored the greater accumulation of dry mass in shoots to the detriment of roots. Probably, the greater accumulation of leaf dry mass of the BRS-Tumucumaque cultivar, due to potassium fertilization, favored greater photosynthetic activity and, consequently, greater accumulation of dry mass in shoots and roots, suggesting that potassium is an important nutrient for growth. which positively influences the accumulation of dry mass of the plant. In addition, the greater growth of the aerial part to the detriment of the roots, indicates a greater investment of photoassimilates in the aerial part, in particular in the leaves, aiming at accumulating energy for the reproductive phase of the plants.

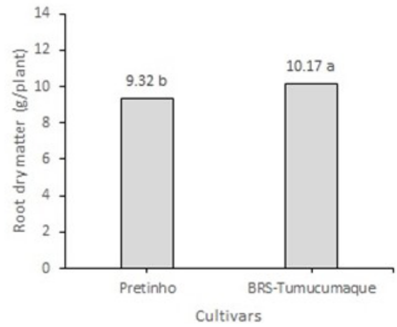


**Figure 8.** Root dry matter (g/plant) as a function of cowpea cultivars. Different letters denote statistical differences at 95% probability.

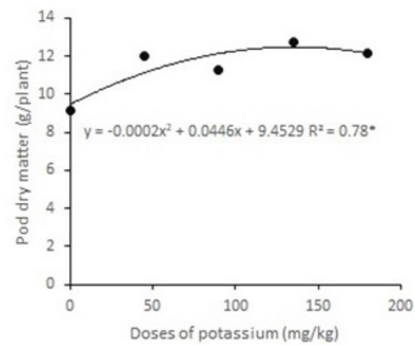


**Figure 9.** Pod dry matter (g/plant) as a function of potassium doses (mg/kg). *Significant at 95% probability.

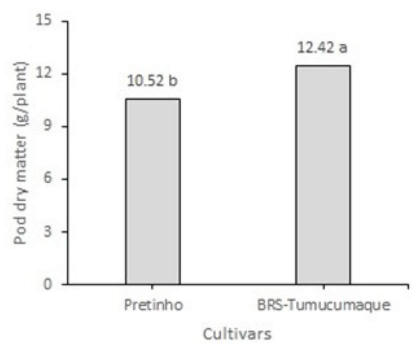


**Figure 10.** Pod dry matter (g/plant) according to cowpea cultivars. Different letters denote statistical differences at 95% probability.

Pod dry matter (PDM) had a positive effect with potassium fertilization, showing a quadratic behavior, in which the dose of 111 mg kg -1 of K provided the maximum production of PDM (11.93 g/plant) (Figure 9). On the contrary, the experiment with the development of cowpea in function of the use of waste from the coffee industry as a source of potassium, the PDM was not significant in function of the dose of K (Lima, 2014).

In a study with cowpea, this variable was significant for most treatments relative to a dose of 140 g of KCl. When K was omitted, the treatments did not produce pods, due to the absence of this macronutrient compromising the productive cycle of the crop (Silva Filho, 2018), since K has a direct impact on the productivity and quality of crops, as it affects the increment weight and grain quality (Dechen and Nachtigall, 2007).

As for the cultivar factor, the pod dry matter (PDM) variable showed significant differences, with the cultivar BRS-Tumucumaque, again, presenting a higher average (12.42 g/plant) in comparison with Pretinho (10.52 g/ plant) (Figure 10). The higher dry mass of pods of the cultivar BRS Tumucumaque suggests that this cultivar is more responsive to potassium fertilization. This, in turn, improves the partition of the dry mass of plants in favor of greater dry mass of pods. These results show that potassium fertilization is essential for production gains, particularly in weathered soils such as the present study, since K is easily leached. BRS-Tumucumaque is an improved semi-upright cultivar that is highly adaptable, so much so that its geographical range ranges from the North and Northeast to the Midwest, while Pretinho is a traditional semi-prostrate cultivar from the state of Pará, which have average grain productivity of 1,100 and 900 kg $ha^{-1}$ under rainfed conditions, respectively. Studies that assess the similarities between improved and traditional cultivars are important, since most farmers have more access to the latter, thus emphasizing differences in production can show a more productive alternative.

In a study of the agronomic performance of cowpea cultivars on the coast of Ceará with deficit irrigation strategies, where 30 kg $ha^{-1}$ of KCl was applied during fertilization, the PDM was not significantly influenced in relation to the cultivars Semper Verde and setentão, with both presenting the highest averages in the treatment without water deficit during the three phenological stages. These results are explained by the negative effects that the water deficit causes in the vegetative and reproductive phase of the crop, resulting in the reduction of dry matter (Araújo, 2014).

## 4. Conclusion

The dose of 90 kg $ha^{-1}$ of K promotes greater growth, while the doses of: 100, 111 and 138 kg $ha^{-1}$ of K have a greater increase in the variables LDM, PDM and SHDM, respectively. In general, the cultivar BRS Tumucumaque shows greater growth and production of cowpea plants. Doses of 90 kg $ha^{-1}$ provided greater height (98.75 cm) and stem diameter (10.0 mm). As for production, the dose of 135 kg $ha^{-1}$ caused greater grain weight gain (5.25 g) and dry mass of pods (13.92 g), and the doses of 90 and 180 kg $ha^{-1}$ induced greater number and length of pods (3.16 pods) respectively. These results show better responsiveness of the BRS Tumucumaque cultivar at doses of 90, 135, and 180 kg $ha^{-1}$ in the type of soil where the study was conducted. The cultivar BRS-Tumucumaque is more responsive to potassium fertilization than the cultivar Pretinho. In addition, K seems to improve the dry mass partition in the cultivar BRS - Tumucumaque, in favor of gains in pod production.

## Acknowledgements

To "Federal Institute of Education, Science, and Technology of Amapá (IFAP)" for the granting of scholarships, making it possible to carry out the work.

## References

ARAÚJO, M.E.B., 2014. *Estratégias de irrigação deficitária no desempenho agronômico de cultivares de feijão-caupi no litoral cearense*. Fortaleza: Universidade Federal do Ceará, 81 páginas. Dissertação de mestrado em Engenharia Agrícola/Irrigação e Drenagem.

BASTOS, R.L.G., UCHÔA, M.R., SILVA, D.A., MARIANO, A.B.R., VIANA, T.V.A., AZEVEDO, B.M., AZEVEDO, J. and SOUSA, P.G.R., 2020. Efeito da utilização de biofertilizantes na produção de biomassa de cultivares de feijão-fava. *Brazilian Journal of Development*, vol. 6, no. 4, pp. 19748-19757. http://dx.doi.org/10.34117/bjdv6n4-225.

BATISTELLA FILHO, F., FERREIRA, M.E., VIEIRA, R.D., CRUZ, M.C.P.D., CENTURION, M.A.P.D.C., SYLVESTRE, T.D.B. and RUIZ, J.G.C.L., 2013. Adubação com fósforo e potássio para produção e qualidade de sementes de soja. *Pesquisa Agropecuária Brasileira*, vol. 48, no. 7, pp. 783-790. http://dx.doi.org/10.1590/S0100-204X2013000700011.

BRASIL, E.C., CRAVO, M.S. and VIÉGAS, I., 2020. *Recomendações de calagem e adubação para o estado do Pará*. 2. ed. Brasília, DF: Embrapa.

CLAESSEN, M.E.C. 1997. *Manual de métodos de análise de solo*. 2. ed. Rio de Janeiro: Embrapa-CNPS, 212 p.

COMPANHIA NACIONAL DE ABASTECIMENTO - CONAB, 2022. *Acompanhamento da safra brasileira de grãos. Safra*, vol. 10, no. 1, pp. 77.

CRAVO, M.S., SMYTH, T.J. and SOUZA, B.D.L., 2006. Nível crítico de potássio para feijão-caupi em latossolo amarelo textura média do Nordeste paraense. In: *Anais do 1° Congresso Nacional de Feijão-Caupi; Anais da 6° Reunião Nacional de Feijão-Caupi*. 2006, Teresina. Teresina: Embrapa Meio-Norte. p. 1-7.

DANIEL, E., ROSE, C.J. and JOHN LAMB, A., 2016. *Potassium for crop production*. St Paul: University of Minnesota Extension.

DANTAS, J.P., MARINHO, F.J.L., FERREIRA, M.M.M., AMORIN, M.S.N., ANDRADE, S.I.O. and SALES, A.L., 2002. Avaliação de genótipos de caupi sob salinidade. *Revista Brasileira de Engenharia Agrícola e Ambiental*, vol. 6, no. 3, pp. 425-430. http://dx.doi.org/10.1590/S1415-43662002000300008.

DECHEN, A.R. and NACHTIGALL, G.R., 2007. Elementos requeridos à nutrição de plantas. In: R.F. NOVAIS, V.H.A. VENEGAS, N.F. BARROS, R.L.F. FONTES, R.B. CANTARUTTI and J.C.L. NEVES. *Fertilidade do solo.* Viçosa: Sociedade Brasileira de Ciência do Solo. pp. 92-132.

ERNANI, P.R., ALMEIDA, J.A. and SANTOS, F.C., 2007. Potássio. In: R.F. NOVAIS, V.H. ALVAREZ V., N.F. BARROS, R.L. FONTES, R.B. CANTARUTTI and J.C.L. NEVES, eds. *Fertilidade do solo.* Viçosa: Sociedade Brasileira de Ciência do Solo, pp. 551-594.

FREIRE FILHO, F.R., RIBEIRO, V.Q., ROCHA, M.M., SILVA, K.J.D., NOGUEIRA, M.S.R. and RODRIGUES, E.V. 2011. *Feijão-caupi no Brasil:* produção, melhoramento genético, avanços e desafios. Teresina: Embrapa Meio-Norte.

GALEAZZI, M.A.M., 2016. *Cultivo do feijoeiro submetido a diferentes doses de Adubação potássica em latossolo vermelho.* Erechim: Universidade Federal da Fronteira Sul, 19 p. Trabalho de Conclusão de Curso (Bacharelado em Agronomia).

GALVÃO, J.R., FERNANDES, A.R., MELO, N.C., SILVA, V.F.A. and ALBUQUERQUE, M.P.F., 2013. Sistemas de manejo e efeito residual do potássio na produtividade e nutrição do feijão-caupi. *Revista Caatinga*, vol. 26, no. 2, pp. 41-49.

LIMA, L.K.S., 2014. *Desenvolvimento do feijão caupi em função da utilização de resíduo da indústria do café como fonte de potássio.* Fortaleza: Universidade Federal do Ceará, 79 p. Dissertação (Mestrado em Agronomia/Fitotecnia).

MALAVOLTA, E., 2006. *Manual de nutrição mineral de plantas*. São Paulo: Editora Agronômica Ceres.

MARSCHNER, H., 1995. *Mineral nutrition of higher plants*. 2nd ed. London: Academic Press.

MELÉM JÚNIOR, N.J., FONSECA, I.C.B., BRITO, O.R., DECAËNS, T., CARNEIRO, M.M., MATOS, M.D.F.A., GUEDES, M.C., QUEIROZ, J.A.L. and BARROSO, K.D.O., 2008. Análise de componentes principais para avaliação de resultados analíticos da fertilidade de solos do Amapá. *Semina: Ciências Agrárias*, vol. 29, no. 3, pp. 499-506. http://dx.doi.org/10.5433/1679-0359.2008v29n3p499.

MELO, F.B. and CARDOSO, J.C., 2017. Solos e adubação. In: E.A. BASTOS. *Cultivo de feijão-caupi*. 2. ed. Brasília: Embrapa Meio-Norte.

MENEZES, V., ALVES, S., RODRIGUES, B., MANCINI, C., MENEZES JUNIOR, J.A. and FERREIRA, A., 2019. Avaliação da produtividade de grãos e nodulação em cultivares de feijao-caupi. In: *Anais do III Encontro de Ciência e Tecnologias Agrossustentáveis; Anais do VIII Jornada Científica da Embrapa Agrossilvipastoril*, 2019, Brasília. Brasília: Embrapa, pp.52-55..

OLIVEIRA, A.P., ARAÚJO, J.S., ALVES, E.U., NORONHA, M.A.S., CASSIMIRO, C.M. and MENDONÇA, F.G., 2001. Rendimento de feijão caupi cultivado com esterco bovino e adubo mineral. *Horticultura Brasileira*, vol. 19, no. 1, pp. 81-84. http://dx.doi.org/10.1590/S0102-05362001000100017.

OLIVEIRA, A.P., SILVA, J.A., LOPES, E.B., SILVA, E.E., ARAÚJO, L.H.A. and RIBEIRO, V.V., 2009. Rendimento produtivo e econômico do feijão-caupi em função de doses de potássio. *Ciência e Agrotecnologia*, vol. 33, no. 2, pp. 629-634. http://dx.doi.org/10.1590/S1413-70542009000200042.

OOSTERHUIS, D.M., LOKA, D.A., KAWAKAMI, E.M. and PETTIGREW, W.T., 2014. The physiology of potassium in crop production. In: D.L. SPARKS, ed. *Advances in agronomy*. USA: Elsevier, vol. 126, pp. 203-233.

SANTOS, H.G., JACOMINE, P.K.T., ANJOS, L.H.C., OLIVEIRA, V.A., LUMBRERAS, J.F., COELHO, M.R., ALMEIDA, J.A., ARAUJO FILHO, J.C., OLIVEIRA, J.B. and CUNHA, T.J.F., 2018. *Sistema Brasileiro de Classificação de Solos*. 5. ed. Brasília: Embrapa.

SANTOS, L.A., SORATTO, R.P., FERNANDES, A.M. and GONSALES, J.R., 2015. Crescimento, índices fisiológicos e produtividade de cultivares de feijoeiro sob diferentes níveis de adubação. *Revista Ceres*, vol. 62, no. 1, pp. 107-116. http://dx.doi.org/10.1590/0034-737X201562010014.

SANTOS, L.A.C., SILVA, D.M.P., OLIVEIRA, I.A., PEREIRA, C.E. and CAMPOS, M.C.C., 2017. Crescimento de cultivares de feijão-caupi em solo de terra firme e várzea. *Ambiência Guarapuava*, vol. 13, no. 1, pp. 261-270.

SANTOS, R.D., LEMOS, R.C., SANTOS, H.G., KER, J.C., ANJOS, L.H.C. and SHIMIZU, S.H., 2013. *Manual de descrição e coleta de solo no campo*. 6. ed. Viçosa: Sociedade Brasileira de Ciência do Solo.

SILVA FILHO, A.V.A.,, 2018 *Avaliação da fertilidade de um latossolo textura média no cultivo do feijão-caupi (Vignaguiculata (L.) Walp), cultivar BRS sempre-verde*. Belém: Universidade Federal Rural da Amazônia, 44f. Trabalhode conclusão de curso (Bacharelado em Engenharia Agronômica).

SOUZA, C.A.M., OLIVEIRA, R.B., MARTINS FILHO, S. and LIMA, J.S.S., 2006. Desenvolvimento em campo de espécies florestais em diferentes condições de adubação. *Ciência Florestal*, vol. 16, no. 3, pp. 243-249. http://dx.doi.org/10.5902/198050981905.

SOUZA, L.P.N., PEREIRA, B.F.F., OLIVEIRA, I.J., TUCCI, C.A.F. and NASCIMENTO, J.P., 2018. Adubação fosfatada e potássica: efeito na altura da planta e no diâmetro do caule de mandioca. *Terceira Margem Amazônia*, vol. 3, no. 11, pp. 275-285.

TAVARES, T.C.O., SOUSA, S.A., LOPES, M.B.S., VELOSO, D.A. and FIDELIS, R.R., 2018. Divergência genética entre cultivares de feijão comum cultivados no estado do Tocantins. *Revista de Agricultura Neotropical*, vol. 5, no. 3, pp. 76-82. http://dx.doi.org/10.32404/rean.v5i3.1892.

TRÄNKNER, M., TAVAKOL, E. and JÁKLI, B., 2018. Functioning of potassium and magnesium in photosynthesis, photosynthate translocation and photoprotection. *Physiologia Plantarum*, vol. 163, no. 3, pp. 414-431. http://dx.doi.org/10.1111/ppl.12747. PMid:29667201.

VALENTE, M.A., CAMPOS, A.G.S. and WATRIN, O. S., 2015. Mapeamento dos solos do bioma cerrado do Estado do Amapá. In: *Anais XVII Simpósio Brasileiro de Sensoriamento Remoto - SBSR*, 2015, João Pessoa. São José dos Campos: INPE, pp. 3557-3564.

VIANA, E.M. and KIEHL, J.C., 2010. Doses de nitrogênio e potássio no crescimento do trigo. *Bragantia*, vol. 69, no. 4, pp. 975-982. http://dx.doi.org/10.1590/S0006-87052010000400024.

ZHOU, S., HAN, Y.-Y., CHEN, Y., KONG, X. and WANG, W., 2015. The involvement of expansins in response to water stress during leaf development in wheat. *Journal of Plant Physiology*, vol. 183, pp. 64-74. http://dx.doi.org/10.1016/j.jplph.2015.05.012. PMid:26092364.