

## Cowpea cultivars produced with different phosphorus levels

### Desempenho de cultivares de feijão-caupi em função de doses de fósforo

DOI:10.34117/bjdv7n1-079

Recebimento dos originais: 10/12/2020

Aceitação para publicação: 06/01/2021

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**ABSTRACT**

In order to evaluate the performance of cowpea subjected to doses of phosphorus (P), a study was conducted in the experimental field of the State University of Southwest Bahia, on a Typical Yellow Dystrophic Latosol, using the BRS Guariba and BRS Xiquexique cultivars. The treatments consisted of four doses of P: 0, 60, 120 and 180 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub>. The experimental units were composed of five sowing lines spaced from 0.5 and 0.6 m, with spacing between plants of 0.1 and 0.125 m, respectively, according to the worked cultivar. The experiment was conducted in a randomized block design with three replications. The plants were grown in rain-fed conditions, until they reached the point of harvest. As Flowering was starting, samples were withdrawals to evaluate the dry mass and leaf area yield. At the end of the cycle, the production components of the culture were quantified. The data were subjected to analysis of variance and subsequently, the Polynomial Regression analysis was performed using the Sisvar statistical program at the level of 5% probability. Phosphate fertilization increased the dry matter mass production, the number of pods per plant and grain per pod, as well as increased productivity.

**Keywords:** *Vigna unguiculata*, soil fertility, plant production.

**RESUMO**

Com o objetivo de avaliar o desempenho do feijão-caupi submetido a doses de fósforo (P), foi conduzido um estudo no campo experimental da Universidade Estadual do Sudoeste da Bahia, sobre um Latossolo Amarelo Distrófico Típico, utilizando as cultivares BRS Guariba e BRS Xiquexique. Os tratamentos foram constituídos por quatro doses de P: 0, 60, 120 e 180 kg ha<sup>-1</sup> de P<sub>2</sub>O<sub>5</sub>. As unidades experimentais foram compostas por cinco linhas de semeadura espaçadas de 0,5 e 0,6 m, com espaçamento entre plantas de 0,1 e 0,125 m, respectivamente, conforme a cultivar trabalhada. Para a condução do experimento foi utilizado o delineamento experimental em blocos casualizados, com três repetições. As plantas foram conduzidas em condição de sequeiro, até alcançarem o ponto de colheita. Iniciado o florescimento, foram retiradas amostras para avaliar o rendimento de massa seca e área foliar, ao final do ciclo foram quantificados os componentes de produção da cultura. Os dados foram submetidos à análise de variância e posteriormente, foi realizada a análise de Regressão Polinomial utilizando o programa estatístico Sisvar ao nível de 5% de probabilidade. A adubação fosfatada promoveu aumento na produção de massa da matéria seca, no número de vagem por planta e grão por vagem, bem como elevou a produtividade.

**Palavras-chave:** *Vigna unguiculata*, fertilidade do solo, produção vegetal.

**1 INTRODUCTION**

The cowpea [*Vigna unguiculata* (L.) Walp.], also known as string bean or macassar bean, is widespread in the Northeast region, representing one of the main dietary alternatives for the Brazilian semi-arid region population. As it is a predominant crop among small producers in this region, the low technological level used in crops results in low productivity (Silva et al., 2009; Lima et al., 2007).

Characterized by its rusticity and adaptability, factors that make it possible to develop under common stress conditions in semi-arid regions, cowpea is very responsive to the use of technology and management (Freire et al., 2005).

Currently, motivated by the expressive potential of this crop, large producers in the Midwest region of Brazil have been contributing to raise the national average of cowpea production, however, this value is far below the ideal, bordering around 400 kg ha<sup>-1</sup> in crops that occupy an area greater than 1,250,000 ha, according to the survey carried out by Wander (2013).

Factors such as water restriction and nutritional deficit are commonly seen in small crops in the semi-arid region, however, small changes in crop management, such as the fertilizers use, can cooperate to increase productivity in this region. According to Malavolta (2006), the Oxisols formed in tropical regions have low levels of organic matter and high phosphorus (P) adsorption or fixation capacity, mainly due to the high levels of Fe and Al oxides on their mineralogical composition.

The importance of P for vegetables is related to its active participation in several metabolic processes, constituting molecular structures of nucleic acids, phospholipids, adenosine triphosphate, among others, constituting itself as a key element of metabolic pathways and biochemical reactions. Considering the low availability of P in Brazilian soils, the practice of fertilization assumes a relevant role for the establishment and maintenance of crops (Cecato et al., 2008; Tiritan et al., 2010).

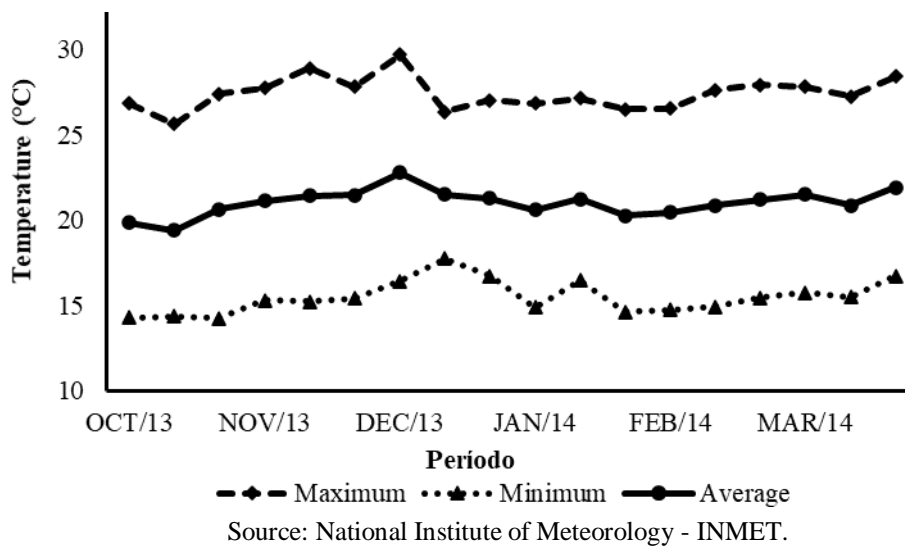
Due to the lack of scientific information about the effects of P on the cowpea crop, recently a greater number of researchers has contributed relevant information. Studies have demonstrated the efficiency of using phosphate fertilizers on vegetative development, nutritional aspects, as well as on production components, especially the productivity of several cowpea cultivars (Bezerra et al., 2009; Coutinho et al., 2014 ; Santos et al., 2011; Silva et al., 2010).

Motivated by the need for concrete information about phosphate fertilization for the crop in the Planalto da Conquista region, as well as to establish the level of P in the soil that provides greater productivity, this work aimed to evaluate the production components of cowpea grown with different doses of P in the municipality of Vitória da Conquista - BA.

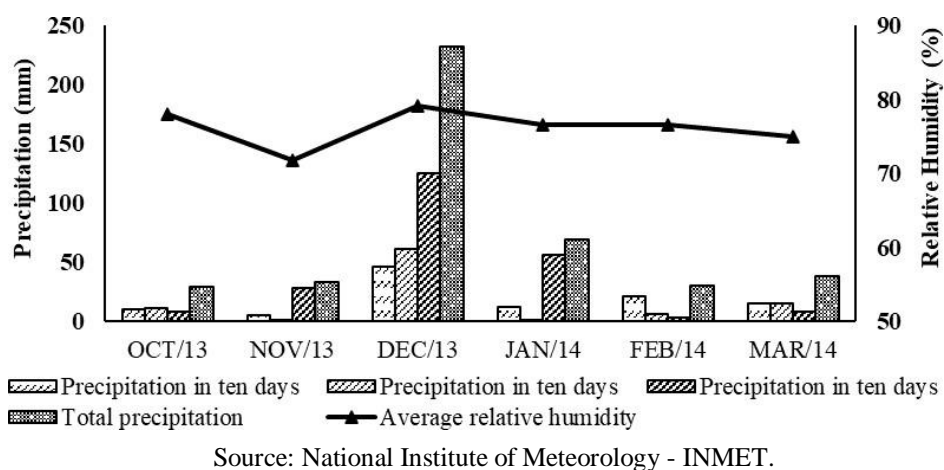
## 2 METHODS AND MATERIAL

The experiment was conducted in the experimental field of the State University of Southwest Bahia (UESB), Vitória da Conquista *Campus*, located at 14 ° 53'18" south latitude, 40°47'53" west longitude, with an altitude of 855 m and a tropical Altitude climate (Cwa), according to Köppen, from November 2013 to February 2014. During this period, a total of 363.30 mm of precipitation and an average temperature of 22.23 ° C (Figures 1 and 2) were recorded.

**Figure 1:** Monthly averages of minimum, average and maximum temperature from October 2013 to March 2014. Adapted from Inmet. UESB, Vitória da Conquista - BA.



**Figure 2:** Monthly averages of precipitation and relative humidity in the period from October 2013 to March 2014. Adapted from Inmet. UESB, Vitória da Conquista - BA.



The soil of the experimental area was classified as Typical Yellow Dystrophic Latosol, and according to chemical and physical analysis (0 - 20 cm), it presented the following characteristics: 20 g dm<sup>-3</sup> of organic matter, pH (H<sub>2</sub>O) of 5,7, 15 mg dm<sup>-3</sup> of P (Mehlich), 0,36, 0,21, 0,9 and 2,2 cmolc dm<sup>-3</sup> of K, Ca, Mg and H + Al, respectively,

60% base saturation, class clay-sandy-sand textural, with 750 g kg<sup>-1</sup> of sand, 190 g kg<sup>-1</sup> of clay and 60 g kg<sup>-1</sup> of silt.

A randomized block design with four replications was used. The treatments consisted of four doses of P: 0; 60; 120 and 180 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub>, in the form of triple super phosphate, applied to the bottom of the sowing furrow. The plots had dimensions of 12.5 m<sup>2</sup> (2.5 m x 5 m), with spacing of 0.5 m between lines and 0.1 m between plants, and 15 m<sup>2</sup> (3 m x 5 m), with spacing of 0.6 m between rows and 0.125 m between plants, for the cultivars BRS Gariba and BRS Xiquexique, respectively.

The soil preparation was done by plowing and harrowing, followed by the demarcation of the experimental units, potassium fertilization according to chemical analysis, application of treatments with P and subsequent sowing on the 15th of November 2014, depositing two seeds in spacing, between plants, defined for each cultivar. The cultivars used were BRS Guariba, characterized by the habit of semi-erect growth, vegetative cycle of 65-70 and white coat, and BRS Xiquexique characterized by the habit of semi-prostrate growth, vegetative cycle of 65-75 and white coat.

The cultivation was developed in rainfed, with supplementary irrigation only in the initial development of the plants, until the expansion of the first trifoliolate leaf and establishment of the plant stand. At 15 days after sowing, thinning was carried out, leaving 10 and 8 plants per linear meter, totaling 120 and 96 useful plants per plot for the BRS Guariba and BRS Xiquexique cultivars, respectively, followed by nitrogen fertilization in coverage, applying 20 kg ha<sup>-1</sup> of N, using ammonium sulfate since the phosphate source used does not provide S. The weed control was performed before flowering by means of manual weeding.

Flowering started, two plants were collected by repetition, divided into its components (leaves and stems), to measure the leaf area using the Area Meter equipment, model LI 3100, manufactured by LI-cor, which were later placed in a circulation oven of forced air at 65° ± 5° C for 72 hours, until constant mass is reached to quantify the dry mass. Non-linear biometric measurements were determined from the values of leaf area, plant dry mass and leaf dry mass, according to Benincasa (2003), using the formulas: LAI (Leaf Area Index) = total leaf area / soil area; SLA (Specific Leaf Area) = leaf area / dry leaf mass and, LAR (Leaf Area Ratio) = total leaf area / total dry mass.

Upon reaching the physiological maturity and humidity of the grains close to 13%, ten plants were harvested in the useful area of the plots to quantify the characteristics: number of pod per plant, number of grains per pod, length of pod, pod mass, grain/pod ratio, mass of 100 grains and productivity, to carry out these observations, we used a

centesimal precision scale and a millimeter graded ruler.

The data were tested for normality and homogeneity of variance, as well as subjected to analysis of variance at the 5% level and Polynomial Regression analysis for P doses at the level of 5% probability, using the Sisvar Statistical Program (Ferreira, 2000).

### 3 RESULTS AND DISCUSSION

According to the results obtained, the treatments used in this study did not show any significant effect for the variables Specific Leaf Area, Leaf Area Ratio, Pod Mass, Grain/Pod mass ratio, 100 Grain Weight, Pod Length and Grain Number per Pod, to cultivate BRS Guariba and, Specific Leaf Area, Foliar Area Ratio, Weight of 100 grains and Pod Length, to cultivate BRS Xiquexique. The variables Dry Mass of the Aerial Part, Leaf Area Index, Number of Pods and Productivity, were significant in both cultivars, also showing a significant effect for the variables of Pod Mass, Grain Mass/Pod Ratio and NGV, for cultivating BRS Xiquexique (Table 1).

**Table 1:** Summary of analysis of variance for the variables dry shoot weight (MSPA), specific leaf area (AFE), leaf area ratio (RAF), leaf area index (IAF), pod mass per plant (MV), grain weight per pod (G/V), weight of 100 grains (P100), average pod length (CVA), number of pods per plant (NV), number of grains per pod (NGV) and grain yield (PROD) of cowpea cultivars according to phosphorus levels. UESB, Vitória da Conquista - BA.

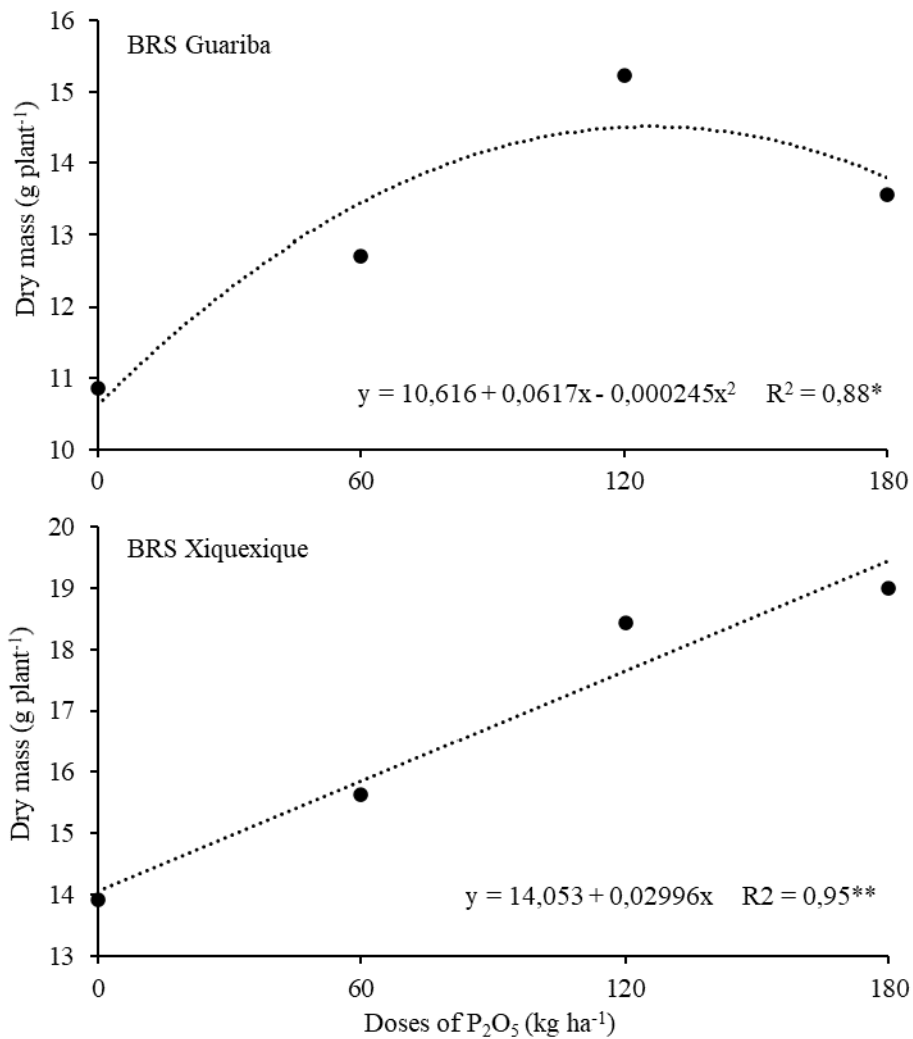
Variation source	MSPA	AFE	RAF	IAF	MV	G/V	P100	CVA	NV	NGV	PROD
<b>BRS Guariba Medium Squares</b>											
Doses of P	13,23**	4,88 <sup>ns</sup>	0,88 <sup>ns</sup>	1,47*	0,08 <sup>ns</sup>	0,0003 <sup>ns</sup>	1,53 <sup>ns</sup>	0,14 <sup>ns</sup>	3,50**	0,16 <sup>ns</sup>	254232,9**
CV%	9,75	10,70	6,81	13,63	13,63	1,76	4,74	3,74	7,64	6,02	4,86
<b>BRS Xiquexique Medium Squares</b>											
Doses of P	22,73**	5,66 <sup>ns</sup>	1,10 <sup>ns</sup>	1,25**	0,31 <sup>ns</sup>	0,001*	0,40 <sup>ns</sup>	0,86 <sup>ns</sup>	41,76**	1,13**	1467913,6**
CV%	10,78	6,34	5,79	11,26	10,50	1,93	5,15	3,56	6,47	3,64	2,8

<sup>ns</sup> Not significant. \* and \*\* Significant at 5 and 1% probability by the F test, respectively.

These results demonstrate a greater sensitivity of the BRS Xiquexique cultivar to low levels of P available in the soil, thus presenting a greater response surface when the availability of this nutrient for plants is increased.

The maximum dry matter production of the aerial part of the cultivar BRS Guariba was achieved with the application of 125.9 kg of P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, resulting in an increase of 6.19 kg ha<sup>-1</sup> of dry mass per kilo of P<sub>2</sub>O<sub>5</sub> applied, while for the BRS Xiquexique cultivar, the highest yield was observed with the application of the maximum studied dose, which provided an increase of 3.98 kg ha<sup>-1</sup> of dry mass per kilo of P<sub>2</sub>O<sub>5</sub> added to the system (Figure 3).

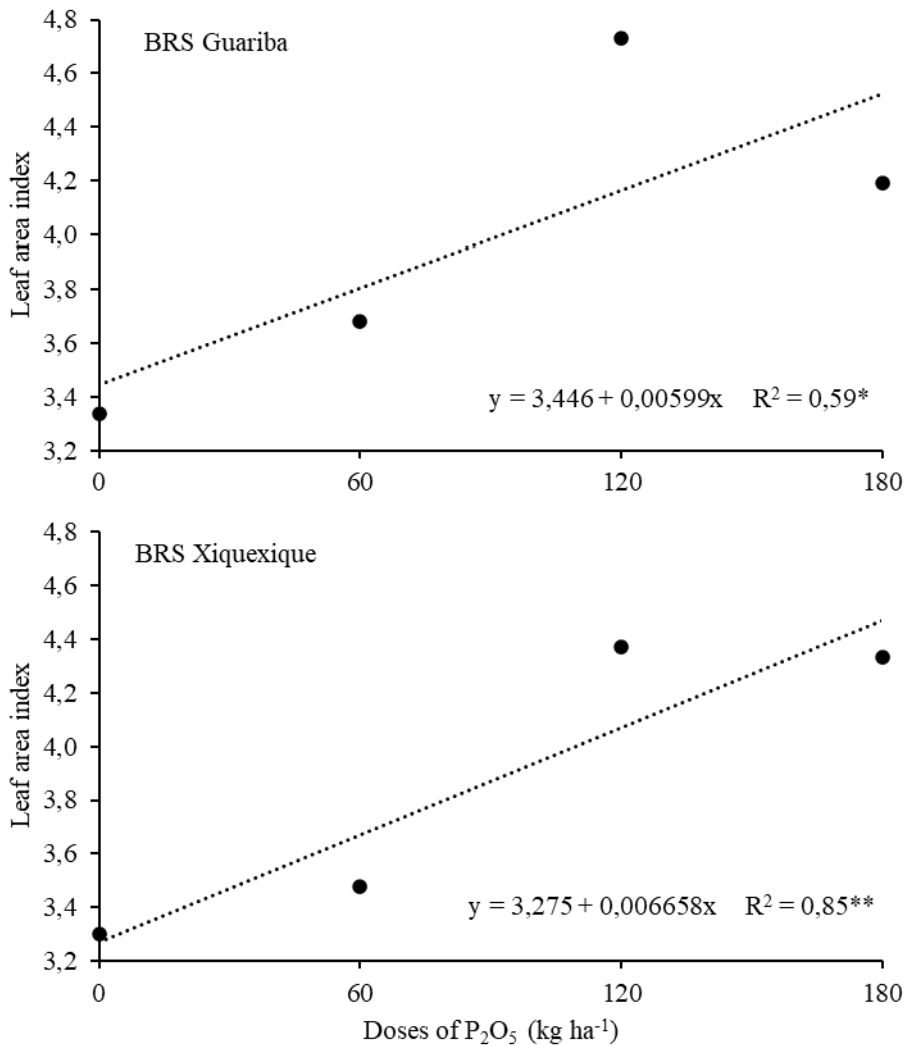
**Figure 3:** Dry mass of the aerial part of two cowpea cultivars as a function of phosphorus levels. UESB, Vitória da Conquista - BA.



Although the BRS Guariba cultivar presents a higher dry matter production per unit of P applied, the linear behavior of the BRS Xiquexique cultivar indicates the possibility of greater response to the application of doses higher than the maximum applied in this study.

Both cultivars showed linear behavior for the variable leaf area index, reaching respective values of 4.52 and 4.47 for the cultivars BRS Guariba and BRS Xiquexique. These values are practically equivalent, however it should be noted that the cultivar BRS Xiquexique had a lower population density, which was compensated with greater vegetative development, as is evident through the greater production of dry mass (Figure 4).

**Figure 4:** Leaf area index of cowpea plants as a function of phosphorus levels. UESB, Vitória da Conquista – BA.

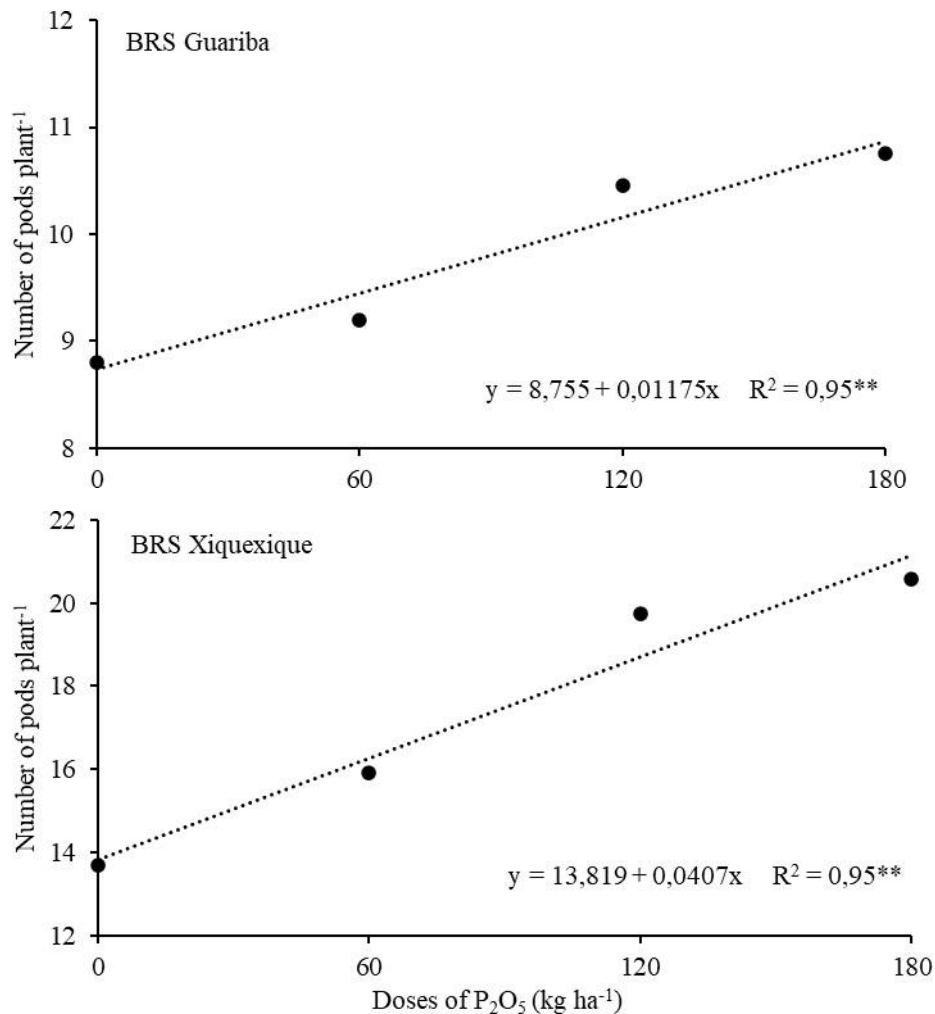


One of the relevance of this characteristic is associated with the ability to cover the soil surface, which gives less proliferation of weeds, as well as protection of the soil, thus it is evident that the application of P contributed to linearly expand the area of soil cover.

The number of pods per plant was increased as the doses of P increased. The linear effect presented by this variable indicates that the use of higher doses of P can contribute to the production of a greater number of pods per plant. Considering the effect of the highest applied dose, compared to the treatment without application of P, the increase generated was 24.2 and 52.9% for the cultivars BRS Guariba and BRS Xiquexique, respectively (Figure 5).



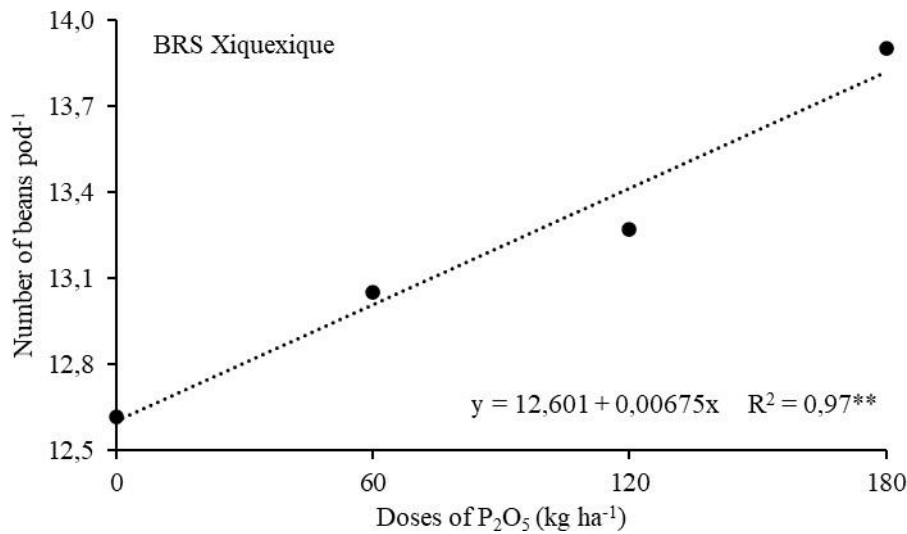
**Figure 5:** Number of pods per cowpea plant as a function of phosphorus levels. UESB, Vitória da Conquista – BA.



Results found by Zucareli et al. (2006) on his studies, corroborate this result, stating that higher doses of P promote a higher number of pods per plant. However, the marked difference observed between cultivars worked, is possibly associated with the characteristics of the growth habit that is directly related to the plant population. Results confirmed by Bezerra et al. (2009), who found a reduction in the number of pods per plant when increasing the population.

Although the significant effect found for the variable number of grains per pod (Figure 6) does not seem to be so marked, the increase of 1.2 grains per pod, obtained with the highest dose in this study, represents an increase of 9.5%, when compared to plants without the addition of P. Considering that the number of pods per plant and number of grains per pod are the factors that most influence productivity, the increase achieved with the application of P doses should be carefully evaluated.

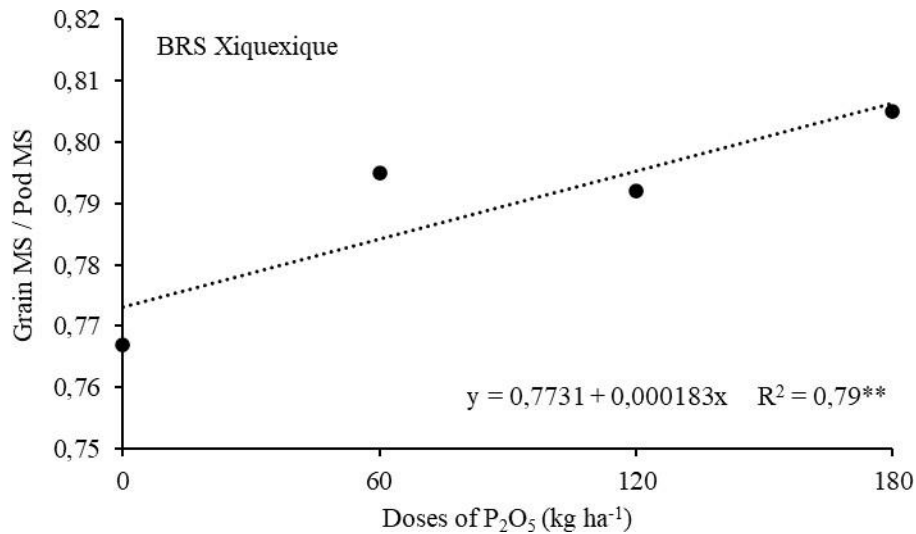
**Figure 6:** Number of grains per pod in cowpea plants as a function of phosphorus levels. UESB, Vitória da Conquista - BA.



Working with different cowpea cultivars, Matoso et al. (2013), found a greater number of grains per pod for the same cultivars in this study, however, the authors attributed this yield to genetic heritability, reporting little influence from their treatments. However, Zucareli et al. (2006) studying doses of P in beans did not have a significant effect for this characteristic, a result opposite to that verified by Coutinho et al. (2014), who detected increases in the number of grains per pod with the application of up to 200 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub>.

The linear effect verified on the percentage of grain mass in relation to the pod, reveals the influence exerted by phosphate fertilization on this variable, providing a slight increase of 4.1% in this relationship (Figure 7).

**Figure 7:** Grain mass per pod mass ratio in cowpea plants as a function of phosphorus levels. UESB, Vitória da Conquista – BA.

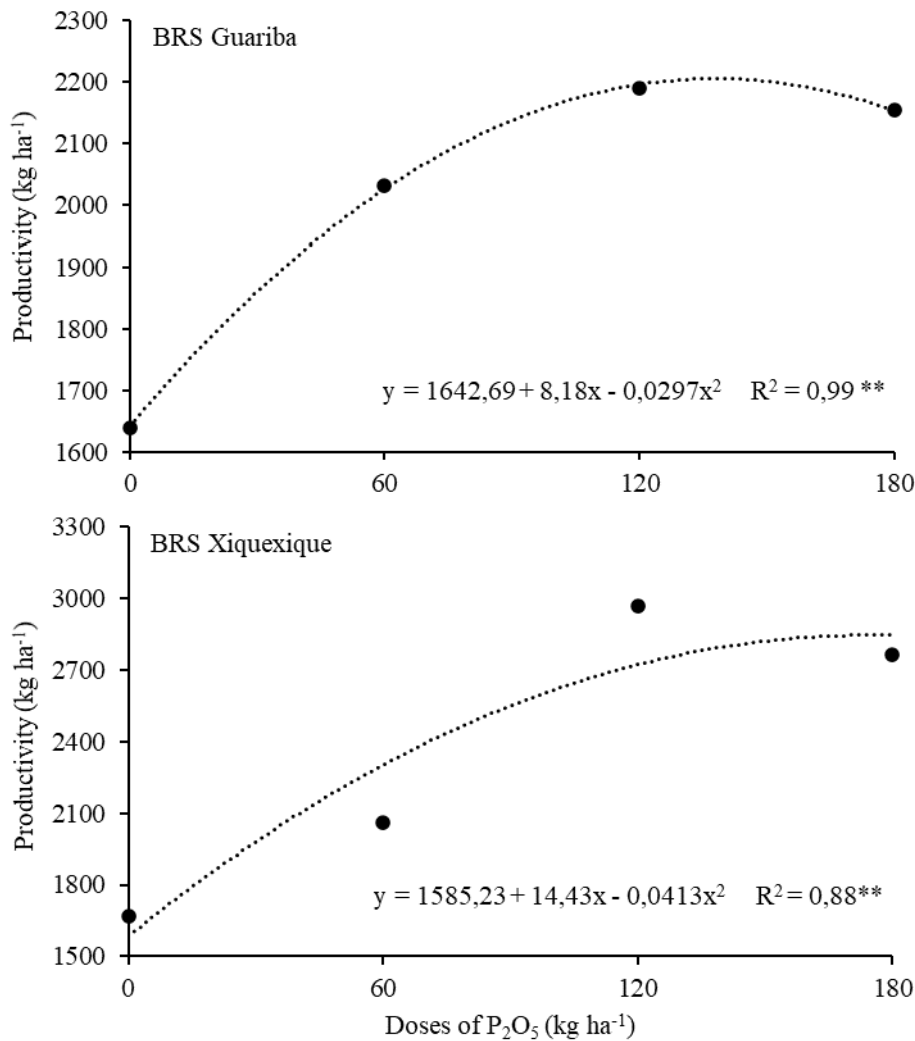


The energy demand during the pod formation and filling phase is quite high, and can be compromised if there is a restriction in the supply of P. Similarly, the availability of P in absorbable forms can contribute to a greater energy supply for the plant in the pod filling, enabling greater grain development.

The yields of both cultivars were influenced by phosphate fertilization, with a quadratic polynomial effect, reaching significant increases with increasing doses. The maximum yield for the cultivar BRS Guariba was reached with the application of 137.7 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub>, providing a yield of 2,219 kg ha<sup>-1</sup> of grains, which represents 35% more compared to the production achieved without the application of P. The cultivar BRS Xiquexique, reached a maximum production of 2,845 kg ha<sup>-1</sup> of grain with the application of 174.6 kg ha<sup>-1</sup> of P<sub>2</sub>O<sub>5</sub>, allowing an increase of 79% regarding the control treatment (Figure 8).

Allied to phosphate fertilization, environmental factors such as availability and distribution of water within the requirement of the crop, as well as temperature within the ideal range recognized as the ideal during its cycle, according to Campos et al. (2010), enabled favorable vegetative development for expressive production.

**Figure 8:** Productivity of cowpea grains as a function of phosphorus levels. UESB, Vitória da Conquista - BA.



The productivity results allow to make inferences as to the yield provided by the phosphate fertilization and, it reveals increases of 4.2 kg ha<sup>-1</sup> for each kilo of P<sub>2</sub>O<sub>5</sub> applied in the cultivar BRS Guariba and of 7.3 kg ha<sup>-1</sup> for each kilo of P<sub>2</sub>O<sub>5</sub> applied to the BRS Xiquexique cultivar. The higher yield in the production of cowpea grains under the influence of phosphate fertilization was also verified by Silva et al. (2010) and Coutinho et al. (2014).

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#### **4 CONCLUSION**

Phosphate fertilization favors vegetative development, increasing the dry mass production of the aerial part.

The number of pods per plant and grains per pod are increased with the application of P on the soil.

The productivity of cowpea cultivars BRS Guariba and BRS Xiquexique are higher with the addition of P in the soil.

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