

Original Research Article

DEVELOPMENT OF COWPEA (*Vigna unguiculata* (L.) Walp.) UNDER DIFFERENT DOSES OF PHOSPHORUS IN A SANDY SOIL WITH AND WITHOUT PLASTER

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Abstract

The cowpea is a crop of great socioeconomic importance in the North and Northeast regions. In these regions, soils tend to be more acidic, causing greater difficulty in root development and absorption of nutrients available in the deeper layers. Another limiting factor is inadequate management or even the non-use of phosphate fertilizers. In this context, the objective of the research was to evaluate the development of cowpea subjected to different doses of phosphorus, with and without the use of agricultural plaster applied on a sandy soil surface. The experiment was carried out from February to June 2018, with a completely randomized block design, 4 replications and 8 treatments. The phosphorus dosages used were 0, 40, 80 and 120 kg ha⁻¹ in soils with and without the use of plaster. To verify results, morphological and productivity parameters were analyzed. The best results were obtained at a dosage of 80 kg ha⁻¹ of phosphorus for treatment with the use of plaster and without the use of plaster. The values decreased with doses greater than 80 kg ha⁻¹ in all analyzed parameters.

Keywords: Productivity, Soil management, Fertilizing, Management.

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1. INTRODUCTION

Vigna unguiculata (L.) Walp., popularly known as cowpea, stands out for its socioeconomic importance for families in the North and Northeast regions of Brazil and has been expanding in the Center-West region [1]. Its main use is in the production of dry or green grains, green fodder, hay, silage, flour for animal feed, and also as green manure and soil protection [2].

Several aspects can influence the low productivity of cowpea, among which the inadequate management of phosphate fertilization stands out [3]. Phosphorus (P) is an essential element in plant metabolism, playing an important role in cell energy transfer, respiration and photosynthesis [4]. Among the nutrients, P is the one that most often limits crop production in soils in the Cerrado region [5].

In order to obtain high productivity, a phosphate fertilization is necessary, which has

generated a greater intensity of searches for doses and forms of use that are more adequate to the cultures and economically viable [6, 7]. Another factor that can compromise productivity is the acidity of the subsoil in depth, an alternative to this problem, according to [8] is the use of gypsum on the surface. Gypsum is the main input for the correction of sodic or alkaline soils, acting in the removal of sodium, an element that degrades the soil structure, through calcium, an element that promotes the improvement of the structure [9].

[10] verified a sharp increase in the percentage of germination and dry matter production in cowpea, with the application of gypsum incorporated into the soil, regardless of the granulometry used. In summary, there is a great possibility of increasing crop production with the use of gypsum. The effect is generally not spectacular, but persists for many years, thus being advantageous from an economic point of view [9].

In this context, the research aims to evaluate the development of cowpea (*Vigna unguiculata* (L.) Walp.) submitted to different doses of phosphorus, with and without the use of agricultural gypsum applied on sandy soil surface.

2. MATERIAL AND METHODS

2.1 Location, characterization and preparation of the experimental area

The experiment was carried out under field conditions in Araguatins - TO, more precisely in the village of Santa Tereza (Figure 1). The municipality is a component of the Bico-do Papagaio mesoregion, located in the northern region of the country. It has approximate coordinates of 05° 0' 00" S and 48° 07' 00" W and an average distance of 612 km from the capital of the State of Tocantins, Palmas. The period for carrying out the work extended between March and June 2018.

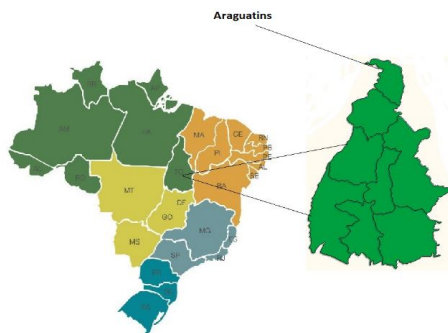


Fig. 1. Location of the municipality of Araguatins.

The rainfall and temperature data during the experiment were obtained from the data system provided by the National Institute of Meteorology – INMET, at the Araguatins – TO meteorological station (Figure 2).

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According to the Köppen-Geiger classification, the climate of the region is of the Aw type, being characterized as a tropical climate with a dry winter season and rainy summer, with an average temperature of 28.5°C and an average annual rainfall of 1500 mm [11].

To prepare the area, weeding was carried out using specific tools to remove debris and weeds present on the site. For chemical analysis (OM - Organic matter, P, K, Ca, Mg, Al,

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(H+A) (Table 1) and physical (Sand, Silt and Clay) (Table 2) analyzes were collected soil samples at depths of 0-20 and 20-40 cm deep.

Table 1: Soil chemical analysis before project implementation.

Dept-h (cm)	pH (H ₂ O)	P		K		Her-e		mg A		H+A		s	T	V	MO
		mg/dm ³		mg/dm ³		mg/dm ³		cmol _c /dm ³		%					
0-20	4.6	2.20	15	0.3	0.1	0.7	1.65	0.44	2.09	20.99	1.44				
20-40	5.2	2.2	21	0.9	0.5	1.2	1.98	1.45	3.43	42.34	0.36				

Table 2: Physical analysis of the soil before project implementation.

Dept-h (cm)	Sand	Clay	silt
	%		
0-20	85.49	7.25	7.26
20-40	64.37	19.61	16.02

2.2 Experimental design and treatments

The experimental design used was completely randomized (DIC), with 4 replications and 8 treatments, totaling 32 plots. Each plot dimension was of size 2.5 m in length and 2 m in width, totaling 5m². The experimental area had a spacing of 0.5m between plots, totaling an area of 224.25 m². The experiment was implemented from March 2018 with the application of plaster that took place 30 days before sowing.

The treatments were T1 - Cowpea cultivation without gypsum and phosphorus (control); T2 - Cowpea cultivation without gypsum application + 40kg P₂O₅ ha⁻¹. T3 - Cowpea cultivation without gypsum application + 80kg P₂O₅ ha⁻¹. T4 - Cowpea cultivation without gypsum application + 120kg P₂O₅ ha⁻¹. T5 - Cowpea cultivation with gypsum application + 0kg P₂O₅ ha⁻¹. T6 - Cowpea cultivation with gypsum application + 40kg P₂O₅ ha⁻¹. T7 - Cowpea cultivation with gypsum application + 80kg P₂O₅ ha⁻¹. T8 - Cowpea cultivation with gypsum application + 120kg P₂O₅ ha⁻¹.

2.3 Conducting the experiment (fertilization and sowing)

For soil correction and plot standardization, fertilizer dosages were defined according to soil analysis before sowing. The application was performed manually 30 days

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before planting, with limestone applied throughout the area and gypsum applied according to the treatments, respectively 1.12 ~~ton-ha⁻¹~~ ha⁻¹ and 0.21 ~~ton-ha⁻¹~~ ha⁻¹, for dolomitic limestone. and agricultural gypsum, being distributed manually and incorporated into the soil with the aid of hoes.

The NPK rates applied at the time of sowing were: 2 0 kg ha⁻¹ of nitrogen in the form of ~~Ammonium of Ammonium~~ Sulfate (NH₄)₂SO₄ - 20% of N), 40 kg of K₂O in the form of Potassium Chloride (KCl - 60% of K₂O) defined according to chemical (Table 1) and physical (Table 2) analyses, and for Phosphorus, P₂O₅ha⁻¹ was applied as Single Superphosphate (SSP - 21% P₂O₅) defined according to the treatments described above. The plots consisted of 4 rows of two and a half meters in length with 10 plants each. The spacing used was 0.25_m between plants and 0.5_m between rows. For evaluations, data on the 6 central plants of each plot were ~~considered, discarding the ends~~ sused to avoid border effect.

Sowing was carried out 30 days after application of limestone and gypsum. The study was carried out manually in pits, with a distance of 0.25 m. Planting fertilization and sowing of 3 seeds per hole were carried out, with thinning at 10 days after emergence, leaving one plant per hole, reaching an approximate density of 80,000 plants -ha⁻¹. The cowpea cultivar used was BR 17 GURGUEIA, which has an indeterminate growth habit, branched size, globose leaves, purple flower color, yellowish dry pod color and greenish seeds, and also has an average cycle of ~~75~~ days, with initial flowering at 43 days after emergence [12].

Weed control was carried out according to the incidence and population of plants, using the mechanical method with the use of hoes and/or manual pulling. To control aphids, insecticide (EFORIA) was applied at the rate of 5 ml / 20L of water. To meet the water needs of the crop, irrigation was performed using a drip tape. Irrigation was carried out from the pod production -phase in the morning on non-rainy days, to prevent the lack of water from interfering with grain yield. The harvest was carried out 68 days after sowing the plants. The pods ~~of 6 plants~~ were manually collected from the 6 plants in the central lines within the useful net area of each experimental plot.

2.4 Evaluated variables

Morphological ~~analyzes~~ were performed at 15, 25 and 40 days after plant emergence. For data collection, 5 plants were randomly chosen within the useful area of each plot, which were properly identified with visible color ribbons so that the following collections were carried out on the same plants.

The parameters analyzed were:

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a) plant height – obtained in centimeters with the aid of a tape measure. The measurement was performed from the base of the plant to the last extended leaf;

b) stem diameter: It was performed using a universal caliper. The measurement was made in millimeters at a height of 5 cm from the base of the plants;

To analyze cowpea productivity components, pods were collected from six central plants in the useful area, from which 10 pods were counted and separated from each plot to evaluate the parameters. The methodology used was according to [13] for the evaluation of agronomic characteristics.

The evaluated parameters are described below:

a) Length of pods (CV in cm): Determined by the average measurement of 10 pods from each plot;

b) Number of pods per plant (NVP): Defined by dividing the total number of pods by the number of plants harvested in the useful net area.

c) Number of grains per pod (NGV): Defined from the average of the grain count of the 10 pods used in the previous variable;

d) Grain weight per plant (PGP);

e) Grain yield (GR) per hectare (kg ha^{-1}): It was defined by multiplying the weight of grains per plant (PGP) by the estimated density of 80,000 plants per hectare;

f) Weight of one hundred grains (PCG - g): After harvesting, the grains were all threshed and homogenized among themselves. Then, 100 grains were separated from each plot and weighed on a precision scale.

2.5 Statistical analysis

The collected data collected were submitted to analysis and variance. The means were compared with each other using the Tukey test at the 5% probability level. Statistical tests were performed with the aid of the SISVAR 5.6 program and the graphs were prepared in Microsoft Excel.

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3. RESULTS AND DISCUSSION

3.1 Morphological parameters of cowpea

For plant height, there were significant differences between the phosphorus doses in the treatments with the use of gypsum incorporated into the soil in the third collection (45 days after emergence) of data (Table 3).

Table 3: Means obtained in plant height (AP) in cowpea cultivar BR 17 GURGUEIA, submitted or not to gypsum application and different doses of phosphorus, with data at 15, 25 and 40 days after emergence (DAE). Araguatins - TO, 2018.

Treatments ⁽¹⁾	AP (cm)		
	15 DAE	25 DAE	40 DAE
1	20 ₂₇ -22 a	43.90 a 36 ₂₇ -75	64, 63 a
2	21 ₂₇ -18 a	a 42 ₂₇ -15	56 ₂₇ -30 a
3 a	22 ₂₇ -17	a 37 ₂₇ -90	62.01 a
4 a	22 ₂₇ -41	a 30 ₂₇ -90	62.03 a
5 a	17 ₂₇ -96	a 35 ₂₇ -87	49 ₂₇ -63 a
6 a	21 ₂₇ -15	a	60.00 ab

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		45 ₂₇ -25	
7	23 ₂₇ -10	a	69.02 b
a			
		34 ₂₇ -80	
8	20 ₂₇ -38	a	57 ₂₇ -84 ab
a			
CV%	18₂₇-48	28₂₇-99	19₂₇-91

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⁽¹⁾ 1: Cowpea cultivation without gypsum application + 0kg P₂O₅/ha ; 2: Cowpea cultivation without gypsum application + 40kg P₂O₅ ha⁻¹ ; 3: Cowpea cultivation without gypsum application + 80kg P₂O₅ ha⁻¹ ; 4: Cowpea cultivation without gypsum application + 120kg P₂O₅ ha⁻¹ ; 5: Cowpea cultivation + Gypsum application + 0kg P₂O₅ ha⁻¹ ; 6: Cowpea cultivation + Gypsum application + 40kg P₂O₅ ha⁻¹ ; 7: Cowpea cultivation + Gypsum application + 80kg P₂O₅ ha⁻¹ ; 8: Cowpea cultivation + Gypsum application + 120kg P₂O₅ ha⁻¹ . *Means followed by the same lowercase letter, do not differ from each other, by Tukey's test at 5% probability. CV%= coefficient of variation.

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In the first two collections, the different levels of phosphorus and the use of gypsum did not significantly influence the growth of the plants, which showed a homogeneous growth in all plots and treatments. From 45 days after emergence (DAE) treatments with gypsum differed significantly from each other, presenting greater height for doses of 80kg.ha⁻¹. The plants presented a growth proportional to the increase of the phosphorus dosage until the dosage of 80kg.ha⁻¹, with a decrease in the dosage of 120kg.ha⁻¹.

[14] found no statistically significant differences for plant height and stem diameter when growing cowpea under different gypsum dosages in a yellow latosol in Northeast Pará. In this context, regardless of the period of development, it is possible that more reaction time is required for the supply of calcium on the surface. As highlighted, the results were significant from 45 DAE. This fact can be justified by the longer time interval available for the action of gypsum on the soil.

For the variable stem diameter (Table 4) there was a significant difference in the second collection at a dosage of 80kg.ha⁻¹ of phosphorus, with a decrease in the stem measurement at the later dosage of 120kg.ha⁻¹, which highlights the dosage of 80kg.ha⁻¹ as the most suitable for obtaining a better stem diameter. In the third data collection, the control showed a significantly higher value than the other treatments, showing a low influence of plaster on this parameter evaluated.

Table 4: Means obtained for stem diameter (DC) in cowpea cultivar BR17 GURGUEIA, submitted or not to gypsum application and different doses of phosphorus, with data at 15, 25 and 40 days after emergence (DAE). Araguatins - TO, 2018.

Treatments	DC (mm)		
	15-DAE	25-DAE	40-DAE

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Table 4: Means obtained for stem diameter (DC) in cowpea cultivar BR17 GURGUEIA, submitted or not to gypsum application and different doses of phosphorus, with data at 15, 25 and 40 days after emergence (DAE). Araguatins - TO, 2018.

Treatments	DC (mm)		
	15 DAE	25 DAE	40 DAE
1	3.98 a	6.22 a	7.77 b
2	4.21 a	5.6 a	7.06 a
3	4.56 a	5.77 a	7.33 a
4	4.59 a	6.12 a	6.77 a
5	3.48 a	5.3 a	6.2 a
6	4.4 a	6.21 a	6.92 a
7	4.63 a	7.42 b	7.76 a
8	3.83 a	6.08 a	6.6 a
CV%:	17.51	15.76	13.05

⁽¹⁾ 1: Cowpea cultivation without gypsum application + 0kg P₂O₅ ha⁻¹; 2: Cowpea cultivation without gypsum application + 40kg P₂O₅ ha⁻¹; 3: Cowpea cultivation without gypsum application + 80kg P₂O₅ ha⁻¹; 4: Cowpea cultivation without gypsum application + 120kg P₂O₅ ha⁻¹; 5: Cowpea cultivation + Gypsum application + 0kg P₂O₅ ha⁻¹; 6: Cowpea cultivation + Gypsum application + 40kg P₂O₅ ha⁻¹; 7: Cowpea cultivation + Gypsum application + 80kg P₂O₅ ha⁻¹; 8: Cowpea cultivation + Gypsum application + 120kg P₂O₅ ha⁻¹. *Means followed by the same lowercase letter, do not differ from each other, by Tukey's test at 5% probability. CV%= coefficient of variation.

There was a significant difference in the second collection at a dosage of 80kg.ha⁻¹ of phosphorus, with a decrease in the stem measurement at the later dosage of 120kg.ha⁻¹, which highlights the dosage of 80kg.ha⁻¹ as the most suitable for obtaining better stem diameter. In the third data collection, the control showed a significantly higher value than the other treatments, showing a low influence of plaster on this parameter evaluated.

The low action of gypsum can be justified by the high solubility presented by gypsum and the form of application may have favored excessive leaching, considering the high permeability of the soil used and the low water and nutrient retention capacity [15].

Another possibility would be the amount of plaster applied. According to [9] the amount of gypsum recommended by official bodies, which are based on analyzes carried out at a depth of 40 cm in the soil, are safe and do not cause damage, but there is evidence that applying higher doses can bring advantageous results.

To prove this hypothesis, it is necessary to carry out a soil analysis at a depth greater than 50 cm to verify chemical barriers and corrective needs. In this context, considering that the dose of gypsum used in this research was based on chemical analysis of the soil, it may not have been sufficient to influence the morphological parameters of the

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crop.

3.2 Cowpea yield analysis

The averages obtained for yield parameters showed significant differences for P doses in almost all aspects evaluated, except for pod length (CV) and number of grains per pod (NGV). That is, gypsum and phosphorus do not significantly interfere with the increase or decrease of these two parameters.

Collaborating with these results, [16], evaluating different doses and forms of phosphorus application in a dystrocohesive yellow oxisol in Roraima, the results obtained showed that there were significant differences for practically all parameters evaluated. Rosal (2013), evaluating the interaction of zinc with the same doses of phosphorus in the present work, found a significant difference for PCG, NVP, and NVP in relation to phosphate fertilization. For the number of pods per plant (NVP) there was were practically no interference of gypsum in the results obtained.

According to Figure 3, the productivity means did not differ significantly between treatments with gypsum application and without gypsum application, except at the rate of 40kg.ha⁻¹. It is possible to observe that the best results were obtained at the dosage of 80kg ha⁻¹.

The behavior of the lines in the graph showed a similarity for the plots with and without gypsum, with an increase in the number of pods up to the dose of 80kg.ha⁻¹ decreasing at higher doses. The maximum number of pods obtained was 12.7 at a dosage of 80kg.ha⁻¹. [17] obtained a maximum of 10 to 11 pods per plant at the maximum applied dose, which was 160kg.ha⁻¹. This difference can be explained by the difference between the cultivars used, which may present different conditions and behaviors. |

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Regarding the weight of one hundred grains (PCG) (Figure 4) it is noted that the treatments with the use of gypsum in the soil, except at the rate of 40kg ha⁻¹, presented statistically higher results than those without application of gypsum.]

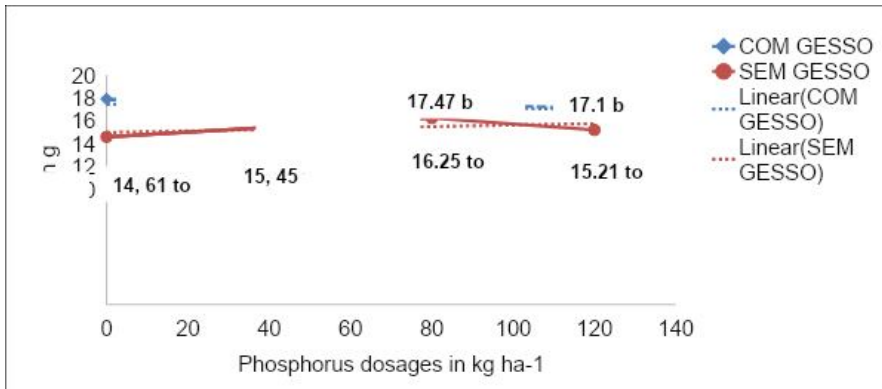


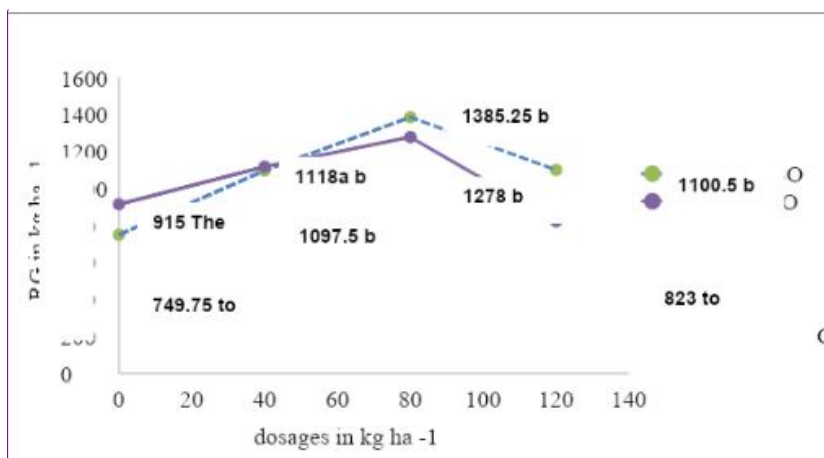
Fig. 4: Averages obtained for the weight of one hundred grains (PCG) in cowpea cultivar BR17 GURGUEIA, submitted or not to the application of gypsum and different doses of phosphorus. Araguatins - TO, 2018.]

Considering that there was practically no statistical difference between the phosphorus dosages, this result can be justified by the action that gypsum exerts on the development of roots in depth, facilitating the availability of nutrients and water for the plant, a factor that increases the absorption of essential substances. throughout the development of the crop, especially during the pod filling period.

[18] state that this fact can be justified by the ability of gypsum to condition the root environment in a way that facilitates root development in depth. This response has been observed in most annual crops and is attributed to the fact that there is a greater distribution of the roots of the crops in the deeper layers, due to the reduction of chemical barriers and greater use of the nutrients available to the plant.

As for the component of grain yield (GR), the results were significantly favorable for the phosphorus doses (Figure 5).

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Fig. 5: Médias obtidas para rendimento de grãos (RG) em Feijão-caupi cultivar BR 17 GURGUEIA, submetidos ou não a aplicação de gesso e diferentes doses de fósforo. Araguatins - TO, 2018.

The crop response to phosphate fertilization depends on soil fertility, being favorable in soils with the absence or low presence of this nutrient.

The maximum productivity obtained was 1385 kg_{ha}⁻¹ with a dose of 80 kg_{ha}⁻¹, with a decrease with excess dose. This result ~~is~~ may be an indication that, under the conditions studied, phosphate fertilization cannot exceed the optimal amount of production.

[18] obtained, applying 80 kg_{ha}⁻¹, a productivity of 1450 kg_{ha}⁻¹ in a dystrophic Haplic Plintisol in the edaphoclimatic conditions of the state of Piauí. [17] obtained an average productivity of 943 kg_{ha}⁻¹ at the rate of 90 kg_{ha}⁻¹ in a dystrocohesive yellow latosol. The difference in the results can be explained by the varied edaphoclimatic conditions and fertility levels of the mentioned soils.

[19] state that, in general, the action of phosphorus in the soil will be influenced by the clay content present. In their studies carried out under the conditions of the state of Amazonas in a very clayey yellow oxisol, 60 kg_{ha}⁻¹ of P₂O₅ was sufficient to raise the

content of this nutrient in the soil to a level considered ideal for the development of the crop.

4. CONCLUSION

From the results obtained in this research, it is possible to notice that for the cowpea crop, the phosphorus dosage that stood out was 80_kg ha⁻¹. This dosage showed better results in practically all parameters evaluated, including yield parameters. As for the use of gypsum, the results were better in treatments with the application of this soil conditioner. However, the results were not so expressive. This fact clarifies the use of gypsum as a long-term benefit in the culture, and can remain acting for years.

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REFERENCES

[1] FREIRE FILHO, FR; LIMA, J.A; RIBEIRA, A. Cowpea beans: technological advances. Brasília: **Embrapa Technological Information**, p. 519, 2005.

[2] EMBRAPA - Embrapa Meio-Norte Production Systems. **Cultivation of Cowpea**. JAN 2003. ISSN 1678-8818 2 Electronic Version.

[3] BLANCO, FF et al. Green corn and cowpea cultivated in intercropping under different irrigation depths and phosphorus doses. **Brazilian Agricultural Research**, Brasília – DF, v. 46, p. 524-530, MAY 2011.

[4] ZUCARELI C.; RAMOS JUNIOR US; BARREIRO, AP; NAKAGAWA J.; CAVARIANI, C.; phosphate fertilization, production components, productivity and physiological quality in bean seeds. **Brazilian Seed Magazine**, vol. 28, n.1, p.09-15, 2006.

[5] CARVALHO, AD; FAGERIA, NK; OLIVEIRA, ID; KINJO, T. Common bean response to phosphorus -application in cerrado soils. **Brazilian Journal of Soil Sciences**. P. 61-67, 1995.

[6] FAGERIA, N.K. Calibration of phosphorus analysis for rice in a greenhouse. **Brazilian Agricultural Research**, Brasília, v.25, p.579-586, 1990.

[7] OLIVEIRA, AP et al. Fava bean production as a function of the use of phosphorus doses in -a Regolithic Neosol. **Brazilian Horticulture**, Brasília - DF, v. 22, no. 3, p. 543-546, JUL-SET 2004.

[8] -PEREIRA, FR da S.; **Ore gypsum associated with phosphorus sources in corn under no-tillage system in the state of Alagoas**. Dissertation – UNESP. Botucatu – SP, 2007.

[9] RAIJ, BV Plaster in Agriculture, **Agronomic Information**, n. 122, 2008.

[10] BARROS, MDFC; BABY, FV; DOS SANTOS, TO; CAMPOS, MCC Influence of gypsum application to correct a saline-sodic soil cultivated with cowpea. **Journal of Biology and Earth Sciences**, v. 9, no. 1, p. 77-82, 2009.

[11] **INMET** - **National Institute of Meteorology**, 2018. Available at: <http://www.inmet.gov.br/portal/> , Accessed: 08 AUG 2018.

[12] -EMBRAPA. Embrapa Meio-Norte Production system. **Cultivation of Cowpea**. MAE 2017. ISSN 1678-8818 2. Electronic version.

[13] FREITAS, RMO; DOMBROSKI, JLD; FREITAS, FCL; NOGUEIRA, NW; PROCÓPIO, IJS. ~~Cowpea production~~Cowpea – under production under summer drought in no-tillage and conventional systems. **Semina: Agricultural Sciences**, Londrina, v. 34, no. 6, supplement 1, p. 3683-3690, 2013.

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Comment [CB45]: Please kindly list the full names of the co-authors of this work.

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[14] ALVES, JDN et al. Agricultural gypsum in cowpea (*Vigna unguiculata*) culture in yellow latosol in northeastern Pará. **Biosphere Encyclopedia**, Goiânia – GO. 01 DEC 2013.

Comment [CB48]: Please kindly list the full names of the co-authors of this work.

[15] SANTOS, HG et al. **Brazilian Soil Classification System**, 2nd ed., EMBRAPA SOLOS, Rio de Janeiro – RJ, 2006.

Comment [CB49]: Please kindly list the full names of the co-authors of this work.

[16] SILVA, AJ et al. Cowpea bean response to doses and forms of phosphorus application in Yellow Latosol in the State of Roraima. **Amazon Act**. vol. 40. p. 31-36, 2010.

Comment [CB50]: Please kindly list the full names of the co-authors of this work.

[17] ROSAL, CJ de S. **Doses of phosphorus and zinc in cowpea crop**. Dissertation, UNESP – Campus de Jaboticabal – SP, 2013.

[18] SALDANHA, ECM; DA ROCHA, AT; DE OLIVEIRA, ECA; OF BIRTH, CWA; FREIRE, FJ Use of mineral gypsum in Oxisol cultivated with sugar cane. **Caatinga Magazine**, v. 20, no. 1, p. 36-42, 2007.

[19] BRAZIL, EC; CRAVO, M. da S. Nutritional aspects and responses of cowpea to liming and fertilization in the state of Pará. In: **NATIONAL CONGRESS OF FEIJÃO-CAUPI**, Recife - PE, 2013.

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