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Cientific Paper

Effect of phosphate fertilization on the initial growth black cowpea

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Abstract

The present study sought to evaluate the initial development of the black string bean submitted to different phosphorus levels and ages. The experiment was installed in an area of the Faculty of Technology CentecCariri - FATEC Cariri Juazeiro, Ceara, Brazil. The assay was used in a greenhouse in pots with a capacity of 7 liters. The bean crop-of-string black was evaluated for 30 Days with five different doses of phosphorus fertilization (0, 88, 176, 264 and 352 kg ha^{-1} superphosphate) in model plot in time, where the plants were harvested at 10, 20 and 30 days after the application of nitrogen fertilization treatments (DAT), setting of an analysis of growth. We assessed the height and stem diameter of plants. It is concluded that the dose of 264 kg ha^{-1} superphosphate promoted greater height and diameter of plants primarily to 30 days of collection.

Keywords: *Vigna unguiculata* (L) Walp.; initial development; fertilization

Efecto de la fertilización fosfatada en el crecimiento inicial del frijol negro de fraile

Resumen

Este estudio evaluó el desarrollo inicial del frijol negro de fraile sometido a fertilización fosfatada y diferentes épocas de cosecha. El experimento se llevó a cabo en un área de la Facultad de Tecnología Centec Cariri - FATEC Cariri, Juazeiro do Norte, Ceará, Brasil. El ensayo fue desarrollado en un invernadero en macetas con capacidad de 7 litros. Se evaluó el cultivo de frijol negro de fraile durante 30 días con cinco dosis diferentes de fertilizantes de fósforo (0, 88, 176, 264 y 352 kg ha^{-1} de superfosfato simples) en el modelo de parcelas subdividido en el tiempo, donde Las plantas se cosecharon a los 10, 20 y 30 días después de la aplicación de de los tratamientos de fertilizantes fosfatados (DAT), consistiendo así en un ensayo de análisis de crecimiento. Se evaluó la altura y el diámetro del tallo de las plantas. Se concluyó que la dosis de 264 kg ha^{-1} de superfosfato promovió una mayor altura y diámetro de las plantas, especialmente a los 30 días de recolección.

Palabras clave: *Vigna unguiculata* (L) Walp.; el desarrollo temprano; la fertilización

Efeito da adubação fosfatada no crescimento inicial do feijão de corda preto

Resumo

No presente estudo buscou avaliar o desenvolvimento inicial do feijão de corda preto submetido à adubação fostatada e diferentes épocas de coleta. O experimento foi instalado em uma área da Faculdade de Tecnologia Centec Cariri – FATEC Cariri, Juazeiro do Norte, Ceará, Brasil. O Ensaio foi conduzido em casa de vegetação em vasos com capacidade de 7 litros. A cultura do feijão de corda preto foi avaliada durante 30 dias com cinco diferentes doses de adubação de fósforo (0, 88, 176, 264 e 352 kg ha^{-1} de superfosfato simples), em modelo de parcela subdividida no tempo, em que as plantas foram colhidas aos 10, 20 e 30 dias após a aplicação dos tratamentos de adubação fosfatada (DAT), configurando um ensaio de

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análise de crescimento. Foi avaliado a altura e diâmetro caulinar das plantas. Conclui-se que a que a dose de 264 kg ha^{-1} de superfosfato simples promoveu maior altura e diâmetro da plantas principalmente aos 30 dias de coletas.

Palavras-chave: *Vigna unguiculata* (L) Walp.; desenvolvimento inicial; adubação

Introduction

In Brazil, mainly on the North and Northeastern regions, the black cowpea constitutes one of the main social and economic alternatives of food supply and employment generation. Among the different agricultural products found on tropical regions, the black cowpea stands out for its high nutritional value, besides the low production cost. It is widely cultivated by small farmers, constituting one of the main components of the human diet, especially on the rural zone (FREIRE FILHO et al., 2005).

The bean cultivation (*Vigna unguiculata* (L) Walp.) has faced some problems on most production regions, due to the low productivity that, probably, has its causes settled on the rudimentary technologies used, on climatic variations and, primarily, on the progressive exhaustion of the soil fertility. Thus, in order to obtain elevated productivities, it is necessary the adequate handling of the soil fertility (PESSOA et al., 1996).

Among the most required chemical elements by the Black cowpea, the phosphorus is the least absorbed macro nutrient and who most influence the culture development. However, in the literature, few were the studies found involving black cowpea and this element (FREIRE et al., 2005; OLIVEIRA, 2010).

Although the phosphorus is a nutrient that the bean most responds to (FILGUEIRA, 2000), little is known, regionally, regarding the quantities to be used, aiming the achievement of satisfactory yields. The low phosphorus concentration in tropical soils generally limits the agricultural production on tropical and subtropical soils, requiring, consequently, that the phosphate fertilization be a constant practice for complementing the required levels by the cultures (MINHONI et al., 1991).

The response to phosphate fertilization depends, among other factors, on the phosphorus availability in the soil, on the availability of other nutrients, on the species and cultivated vegetal variety and on climatic conditions. Thus, the present study aimed to evaluate the initial development of black cowpea subjected to different doses of phosphorus in different seasons.

Material and Methods

The experiment was installed in an area at the Centec Cariri University of Technology – FATEC Cariri, located in the city of Juazeiro do Norte, Ceará State, with geographical coordinates 07°12′47″S, 39°18′55″W and 377 meters altitude.

Juazeiro do Norte presents a climate between Tropical semi-arid to mild Tropical semi-arid, with average temperature of 24º to 26ºC, having the rainy period from January to May. The average rainfall is of 925 mm (LIMA and RIBEIRO, 2012). Within the climatic types of Köppen (KÖPPEN and GEIGER, 1928), we can identify, as predominant in Juazeiro do Norte, the climatic class BSW'h', that is, Semi-arid climate, with short rainy season, starting on summer and reaching its peak on the transition to the autumn (TAVARES et al., 2009), being under the action of rains derived from the dislocation of the North-Equatorial Mass, which has its major displacement to the South in the autumn (rain maximums in this season and minimums in the spring), presenting temperature superior to 18ºC in the coldest month (SILVA et al., 2010).

The adopted experimental design was of entirely randomized blocks, in scheme of subdivided parcels. The treatments were composed from the combination of five doses of phosphate fertilization (parcels) and three data collecting seasons (sub-parcels), totaling 15 treatments with three replicates.

The fertilization was different regarding the phosphorus application and according to the recommendation of the IFCE Soil Laboratory – Sobral Campus, after the soil analysis, but based on the recommendation of Fernandes (1993). The used treatments were of 0%, 50%, 100%, 150% and 200% of the total recommended and we used as phosphorus source the superphosphate, that is:

P_1 = 45 kg ha^{-1} of urea + 0 kg ha^{-1} of superphosphate + 17 kg ha^{-1} of potassium chloride;

P_2 = 45 kg ha^{-1} of urea + 88 kg ha^{-1} of superphosphate + 17 kg ha^{-1} of potassium chloride;

P_3 = 45 kg ha^{-1} of urea + 176 kg ha^{-1} of superphosphate + 17 kg ha^{-1} of potassium chloride;

P_4 = 45 kg ha^{-1} of urea + 264 kg ha^{-1} of superphosphate + 17 kg ha^{-1} of potassium chloride;

P_5 = 45 kg ha^{-1} of urea + 352 kg ha^{-1} of superphosphate + 17 kg ha^{-1} of potassium chloride;

The collecting seasons were spaced with an interval of 10 days between each collecting, distributed as follows:

E_1 = 10 days after the application of the treatment (DAT) of phosphate fertilization;

E_2 = 20 days after the application of the treatment (DAT) of phosphate fertilization;

E_3 = 30 days after the application of the treatment (DAT) of phosphate fertilization;

On Table 1 we have the soil chemical characterization for the layers of 0.00 – 0.20 m and 0.20 – 0.40 m of depth, from composite samples collected randomly on the area where they were used for filling the vessels of the experiment. The analyses were conducted on the IFCE Soil Laboratory – Sobral Campus, Sobral, CE, according to the methodologies described by EMBRAPA (1997).

The cultivation used was of black cowpea, evaluated during 45 days, comprising the period from November 22 of 2011 to January 5 of 2012. The seeds were acquired from the Barbalha Technological Vocational Center – Barbalha CVTEC. The cultivation was performed in vessels of 7 liters that were filled in its basis with a bit of gravel, in order to avoid the drains clogging, and the rest with sieved soil, on the area belonging to FATEC Cariri.

The planting was conducted sowing four seeds per vessel, whereas 13 days after the germination we did the thinning, leaving two plants per vessel. The vessels were arranged with 0.5 m spacing between the vessel lines, and 0.5 m between vessels.

The irrigation was performed daily and manually, through watering cans, conducted slowly until we observed the water drainage in the vessel, reaching, thus, the field capacity in all vessels.

The evaluations consisted of nondestructive samples for determining the growth variables:

- Stem height of the plant (AC), in cm, determined through height measurements every 10 days, with the use of a graduated ruler of 50 cm, from the soil surface to the apical dominance.

- Stem diameter (DC), in mm, determined every 10 days with the aid of a caliper.

Initially, the variables were subjected to variance analysis (Anova). Later, when significant by the F test, the growth variables, the effects of the phosphate fertilization levels and the collecting seasons were subjected to the regression analysis, aiming to adjust the equations with biological

Table 1. Soil chemical characterizationof the experimental area. Juazeiro do Norte – CE, 2011.

Parameter	Unity	Layer (m)	
		0.00 – 0.20	0.20 – 0.40
Carbon	g kg^{-1}	4.02	2.52
Organic Matter	g kg^{-1}	6.93	4.34
Calcium	mmolc dm^{-3}	49.00	25.00
Magnesium	mmolc dm^{-3}	12.00	19.00
Calcium + Magnesium	mmolc dm^{-3}	61.00	44.00
Aluminum	mmolc dm^{-3}	0.00	0.50
Hydrogen + Aluminum	mmolc dm^{-3}	28.88	36.30
Potassium	mmolc dm^{-3}	64.97	28.25
Phosphorus	mg dm^{-3}	568	2.034
Sodium	mmolc dm^{-3}	0.43	0.19
pH		4.50	6.30
SB	mmolc dm^{-3}	126.40	72.44
CTC	mmolc dm^{-3}	155.28	108.74
V	%	81	67
PST	%	0	0
M	%	0	1
CE	dS m^{-1}	0.49	0.29

The results of the chemical analyses served as basis for the treatments with phosphate fertilization applied throughout the cultivation cycle of black cowpea.

meanings.

In the case of significant effects between the interaction of two factors (phosphate fertilization levels and collecting seasons), we conducted the response surfaces.

On the regression analysis, the equations that better adjusted to the data were selected based on the significance of the regression coefficients at 1% (**) and 5% (*) probability, by the F test, and at the higher determination coefficient (R^2).

The studies of variance and regression analyses were performed with the aid of Excel spreadsheets, using the software "ASSISTAT 7.5 BETA" (SILVA & AZEVEDO, 2009). For the construction of graphs and determination of surface equations of response we used the software "Table Curve 3D v.4.0".

Results and Discussion

The result of the variance analysis of stem height and diameter of the black cowpea, subjected to different doses of phosphorus in different seasons, can be visualized on Table 2. It is possible to observe that a significant interaction at the level of 1% occurred, both for height and diameter of the cowpea stem.

It is possible to see at Figures 1 and 2 a quadratic polynomial behavior on height and diameter of the cowpea stem, when subjected to crescent doses of phosphorus. Such behavior on the bean growth was also observed by several authors (OLIVEIRA *et al.*, 2001; ARAÚJO *et al.*, 2005; VALADÃO JÚNIOR *et al.*, 2008; OLIVEIRA, 2010).

It is possible to observe on Figure 1 that the higher phosphorus dose (352 kg ha^{-1} of superphosphate, the equivalent to 63.36 kg ha^{-1} of P_2O_5) promoted a reduction of the stem height of the bean plant. The same behavior on the stem height was observed by Oliveira (2010), who found a reduction on the height when subjected to the highest treatment of phosphorus doses applied in his research (210 kg ha^{-1} of P_2O_5).

We observed a crescent linear behavior on the stem height and diameter, during the evaluation seasons (Figures 3 and 4), since at 30 days of collecting, the cowpea plants presented better vegetative performance.

According to Oliveira et al. (2003), the height and average number of leaves per plant has little direct importance on the plant selection, when it is intended to obtain productivity increase.

Both in the height variety and the stem diameter, it was already expected the highest values on the last collecting dates, and are proven by Oliveira (2010), studying the effect of different phosphorus doses and water depths on the growth and productivity of the bean plant.

Regarding the interaction between the factors of phosphate fertilization and collecting season (P x E), there was a crescent behavior, where the plant went from an average stem height of 11.25 cm, without the superphosphate application at 10 DAT, to 30.87 cm, with the superphosphate dose of 352 kg ha^{-1} at 30 DAT, obtaining, thus, an increment of 174.43% (Figure 5).

Analyzing the behavior, we verified extremely negative effects, being critic for the levels of 0 kg ha^{-1} of Superphosphate, occurred in the whole cultivation cycle. Hereupon, it is clearly evidenced that the phosphorus required by the culture is demanded

Table 2. Summary of the variance analyses for the stem height (AC) and stem diameter (DC) of the cowpea, in function of doses of phosphate fertilization and the collecting seasons.

Variation source	GL	Mean square	
		AC (cm)	DC (mm)
Phosphorus levels (P)	4	123.45702**	5.47686**
Collecting season (E)	2	683.03017**	19.79072**
Interaction P x E	8	17.15690**	1.79378**
Residue (P)	10	1.74952	0.15783
Residue (E)	20	0.93795	0.24725
CV (N)	(%)	6.35	7.26
CV (E)	(%)	4.65	9.09

(**) Significant effect at 1% and (*) at 5% probability; (^{ns}) non significant at the level of 5% probability by the F test

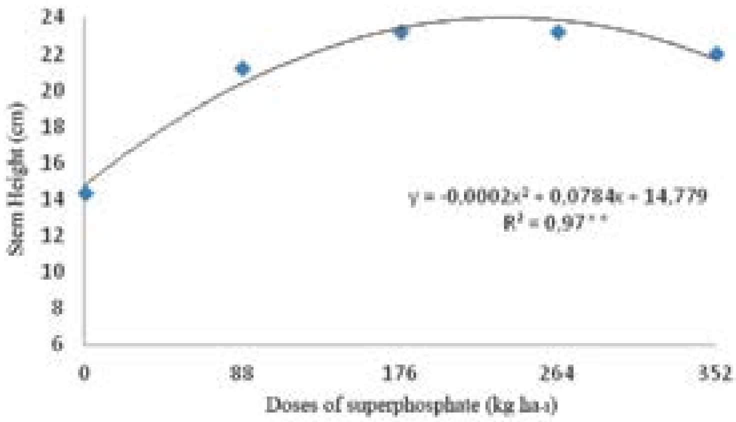


Figure 1. Height of the cowpea stem with different doses of phosphate fertilization.

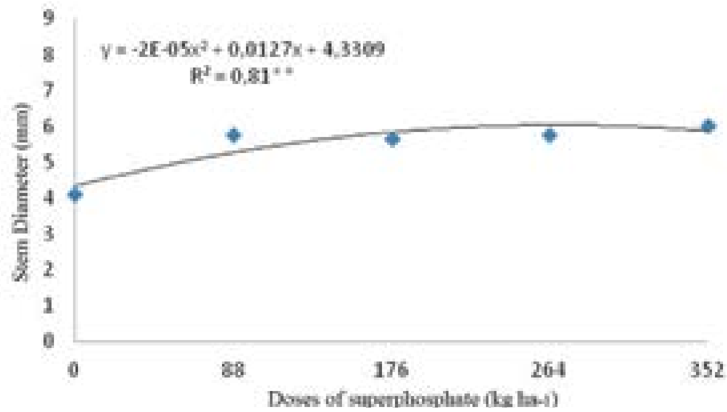


Figure 2. Diameter of the cowpea stem with different doses of phosphate fertilization.

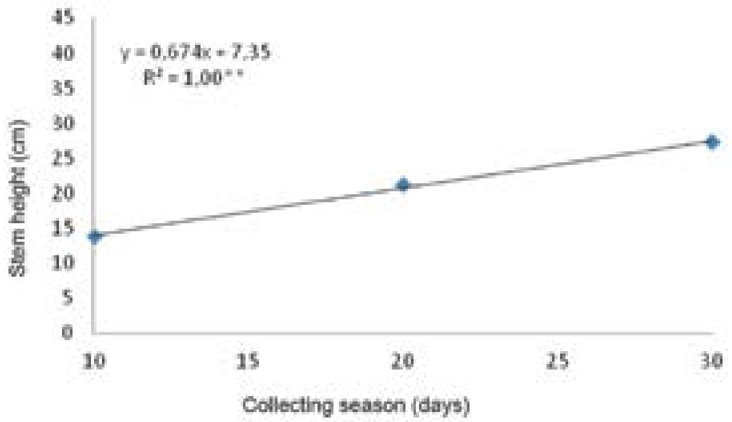


Figure 3. Stem height of the black cowpea with different collecting seasons of data.

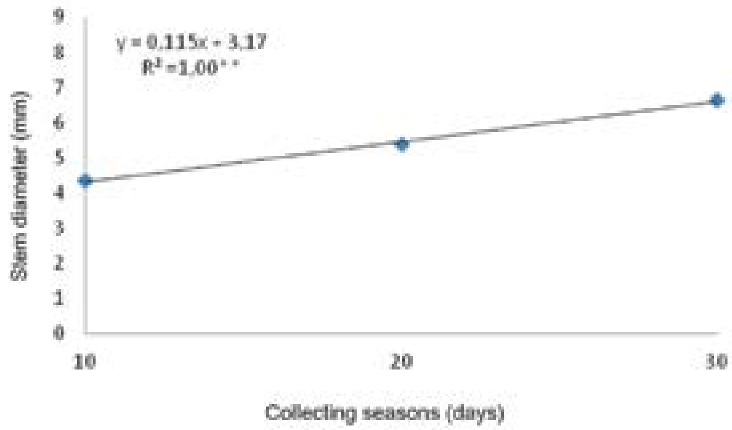
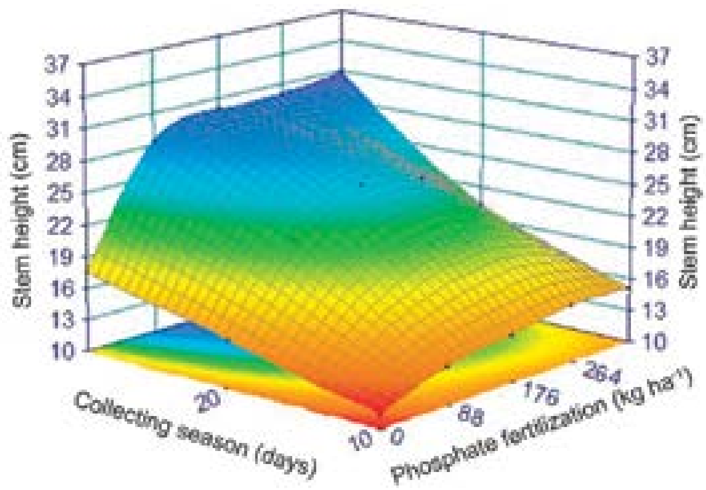


Figure 4. Stem diameter of the black cowpea with different collecting seasons of data.



$$z = 26{,}35717^{**} + 0{,}07846x^{**} - 0{,}00017x^{2**} - \frac{189{,}48463^{**}}{y}$$

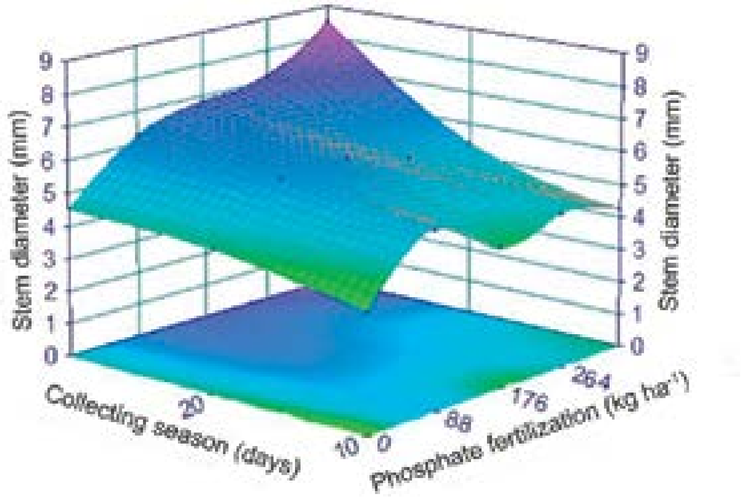
Where: z is the stem height, in cm; x is the phosphate fertilization, in kg ha^{-1}; y is the data collecting season (DAT), in days; (**) Significant effect at 1% and (*) at 5% probability; (ns) non significant at the level of 5% probability by the F test.

Figure 5. Stem height of the black cowpea with interaction of the factors: phosphate fertilization x data collecting season.

since the first days of germination. These results are in accordance with the literature (GRANT *et al*., 2001; OLIVEIRA, 2010), where it is recorded that the P supply is essential since the early stages of the plant growth.

Oliveira (2010), studying phosphorus doses varying from 0 to 210 kg ha^{-1}, found a quadratic effect of height, stem diameter and number of leaves on cowpea cultivation, causing reduction on the height, diameter, foliar area and number of leaves per plant. When these variables were evaluated in time (30 to 65 days after the sowing), we observed a linear effect for both variables. However, there was no interaction between the two factors (phosphorus and season).

On the stem diameter, at the interaction between the factors of phosphate fertilization and collecting season (P x E), there was a crescent behavior, where the plant went from a stem diameter of 3.5 mm, without the application of superphosphate at 10 DAT, to 8.52 mm with the superphosphate dose of 352 kg ha^{-1} at 30 DAT, obtaining, thus, an increment of 143.33% (Figure 6).



$$z = 2{,}39333^{**} + 0{,}00440x^{**} + 0{,}11517y^{**} R^2 = 0{,}70^{**}$$

Where: z is the stem diameter, in mm; x is the phosphate fertilization, in kg ha^{-1}; y is the data collecting season (DAT), in days; (**) Significant effect at 1% and (*) at 5% probability; (^{ns}) non significant at the level of 5% probability by the F test.

Figure 6. Stem diameter of the black cowpea with interaction of the factors: phosphate fertilization x data collecting season.

Conclusion

In the study conditions, we concluded that the interaction between phosphorus dose and season provided higher vegetative performance on the black cowpea, this performance being more evident on the dosage of 264 kg ha^{-1} of superphosphate at 30 days of cultivation.

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