Original Research Article

Development Of Young Plants Of Pumpkin In Different Sources And Dosages Of Phosphorus

ABSTRACT

Aims: The research aimed to analyze the effect of different dosage and sources of phosphorus in growth and development of young plants of pumpkins (*Cucurbita moschata*) 'jacarezinho' cultivar.
Study design: The experimental design utilized was the completely randomized with the factorial scheme 5x3 constituted by five dosages of P2O5 (0; 22.5; 45; 67.5 e 90 kg.ha^{-1}) and three phosphate sources (Simple superphosphate, Triple superphosphate and Natural phosphate of ARAD) with three repetitions.
Place and Duration of Study: The experiment was performed in a greenhouse at field area at Federal Rural University of Amazônia in the Capitão Poço City, Pará State. The research was carried out from March to April, year of 2016.
Methodology: The analyzed variables were plant height (PH), stem diameter (SD), number of leaves (NL), fresh root mass (FRM), fresh aerial mass (FAM), dry aerial mass (DAM) and dry root mass (DRM) at 30 days after sowing. The average of dosages x sources interactions were submitted the regression analyze ($P<0.05$).
Results: There was a significant response to the interaction dosage x source for the PH, FAM and DAM. However, for the SD, there was a significant response only to the dose factor, with linear response. The dosage at 0 t ha^{-1} showed the worst response in all variables. ARAD was the source that had the worst performance in the analyzed variables in comparison to others sources.
Conclusion: Young plants of pumpkins were significantly influenced by phosphate fertilization.

Keywords: Agriculture, Cucurbita moschata; Phosphate fertilization; vegetables.

1. INTRODUCTION

Between the cultivated species of the Cucurbitaceae's family, the pumpkin (*Cucurbita moschata*) occupies a relevant position in agribusiness, being one of the most consumed vegetables in Brazil [1]. This vegetable presents a fruit of globular shape, with average weight of 2 kg to 3 kg, herbaceous stem, large dark green leaves. Its pulp is yellow, rich in nutrients as vitamin A and B complex, including calcium, iron magnesium, potassium and zinc [2]. Also presents good quality for consumption, conservation and flavor [3].

According to [4] the world production of pumpkins has grown from 21.4 million tons in 2006 to 25.2 million tons in 2014 with an average yield of 13.4 t.ha^{-1}. In Brazil, there are few data about pumpkin's commercialization wherein the lastest information available is from of 2006 that show more than 127,000 farms harvested 84 thousand hectares of pumpkins (5.24% of the world harvested area), they produced 398 thousand tons (1.86% of world production), with average yield of 4.5 $t.ha^{-1}$, below the world average (12.5 to 13.5 $t.ha^{-1}$) [5].

Vegetables require supply of nutrients in quantities satisfactory for their perfect growth and development that result in adequate yields. One of the factors that cause a decrease in productivity is unbalanced mineral nutrition that directly influences the production and the final quality of the harvest.

Phosphorus (P) is one of nutrients more demanded by plants due to its performance in plant metabolism. This element plays a role in root growth [6-7], metabolic processes such as ATP's and nucleic acids' formations and photosynthesis [8-9] that result in high quality of the crops. However, the majority of Brazilian soils have low natural fertility and high phosphorus fixation capacity [10-11].

There are a few researches about the effect of phosphorus dosage and source of this nutrient in development and yield of vegetables. [12] when applied P_2O_5 dosage between 245 and 284,6 $mg.dm^{-3}$ of Simple superphosphate (SS) in radish crops cultivated at Red Latosol verified higher plant height and dry aerial mass. [13] have realized a research with phosphorous omission at nutritive solution in beet crop and they found high purplish on the leaves and roots, low plants growth and paralyze of roots growth. [14] have observed that dosage of 340 $mg.dm^{-3}$ from Triple Superphosphate (TSP) at Dystrophic Red Latosol has caused increase of P in the leaves and fresh root mass in beet crop.

According to [15] phosphorus limitations at the beginning of vegetative cycle can result in limitations in roots and aerial part development that the plants may not recover even increasing the P supply. Although, the high importance about phosphate fertilizing there is a lack of knowledge in relation to phosphorus necessities in young plants of pumpkins in Brazilian Amazon region. Therefore, the determination of ideal dosage for this crop is very important to seedling production system.

Another important aspect is the best choice of phosphate sources to be used because the inadequate choice can be promote yield reduction. It knows there are many phosphate sources can be used in agriculture, such as, Simple and Triple superphosphate. [16] verified those soluble phosphates, as Simple and Triple superphosphate show more performance at phosphorus supply at annual crops.

Besides soluble sources, there are natural phosphates that are insoluble in water, show slow liberation of P in soil solution and give more P supply to the plants overtime. [17] report that organic agriculture principles do not allowed the use of soluble fertilizers made of industrial processes. The natural phosphates and thermophosphate are options that may be used in phosphate fertilizers in agriculture systems.

Thus, it is important news performance about this theme with objective to find news viable strategies for the farmers. The research aimed to analyze the effect of different dosage and sources of phosphorus in growth and development of young plants of pumpkins (*Cucurbita moschata*) 'jacarezinho' cultivar.

2. MATERIAL AND METHODS

The experiment was performed in a greenhouse at field area at Federal Rural University of Amazônia, Capitão Poço Campus, in the Capitão Poço City, Pará State (1°44'39" S; 47°3'26" W, altitude 73 m). The research was carried out from March, 24 to April, 24, year of 2016. The soil used in this research is classified as Dystrophic Yellow Latosol [18] and showed the following chemical characteristics: pH (water) = 4.9, M.O = 7.86 $g.kg^{-1}$, P = 3,0 $mg.dm^{-3}$, K = 15,0 $mg.dm^{-3}$, Na = 8.0 $mg.dm^{-3}$, Ca = 0.6 $cmol.dm^{-3}$, Ca + Mg = 0.8 $cmol.dm^{-3}$, Al = 0.8 $cmol.dm^{-3}$, H + Al = 3.96 $cmol.dm^{-3}$. According to the Köppen classification, the regional climate is classified as the Ami type (tropical altitude).

We used pumpkins seeds of 'jacarezinho' cultivar and to overcome their dormancy were used soaking in distilled water for a period of 24 hours. After this step, five seeds per pot with 2 L capacity were sown.

The experimental design utilized was the completely randomized with the factorial scheme 5x3 constituted by five dosages of P_2O_5 and three phosphate sources with three repetitions those results in 45 experimental units. The dosages tested were 0; 22.5; 45; 67.5 e 90 $kg.ha^{-1}$ and the sources were Simple superphosphate (SS) with 18% of P_2O_5, Triple superphosphate (TSP) with 44% of P_2O_5 and Natural Phosphate of ARAD (ARAD) with 33% of P_2O_5. The irrigation was applied once a day to keep the soil moisture nearby the field capacity, by use of manual watering can. The choice of P_2O_5 dosages was realized according to Fertilization Manual of Pará State that indicates the dosage of 90 $kg.ha^{-1}$ de P_2O_5 for pumpkins [19].

In March 24, was performed the sowing and in the tenth day was realized the cutting of young plants showed less vigorous, following a criterion of uniformity of aerial part, leaving one plant per pot. At 30 days after sowing were carried out the following growth and development variables: plant height (PH), was measured from the surface of the soil to the top of the plant with a millimeter ruler, stem diameter (SD), was measured with use of a pachymeter at 5 cm above the ground, number of leaves (NL), were performed by simple count, fresh root mass (FRM), obtained by weighing the roots in a precision balance and fresh aerial mass (FAM), obtained by weighing leaves + stem, in a precision balance. Also we analyzed the dry aerial mass (stem + leaves) (DAM) and dry root mass (DRM) by using a forced air circulation oven at a temperature of 65 °C until a constant mass and then the material was weighed on precision digital balance.

The data were evaluated using the Shapiro-Wilks (P>0.05) and Levene (P>0.05) tests to verify the normality and homoscedasticity assumption. Next, they were submitted at variance analyze and the average were compared by F test (P<0.05) by using SISVAR software [20]. Finally, the average of dosages x sources interactions were submitted the regression analyze (P<0.05) [21].

3. RESULTS AND DISCUSSION

The variance analyze shows that there was significant effect of dosage x sources interaction for the plant height (PH) (P<0.05). But for number of leaves (NL) and stem diameter (SD) there were significant effect just for the isolate factors (Table 1).

Table 1. Summary table of variance analysis of the mean squares (MS) for plant height (PH) number of leaves (NL), stem diameter (SD) of young plants of pumpkins in function of dosages and sources of phosphorus

F.V	DF	Mean Squares (MS)		
		PH	NL	SD
DOSAGES	4	29.02**	17.41**	0.01*
SOURCES	2	17.25**	12.35**	0.00^{NS}
DOSAGES*SOURCES	8	6.36*	2.24^{NS}	0.01^{NS}
Error	30	2.60	1.24	0.00
CV (%)		16.24	19.61	11.44

**Significant at the 5% level of error probability, **Significant at the 1% probability level of the error and NS Not significant at the 0.05 level of probability by the F test. F.V: sources of variations; DF: degrees of freedom.*

In relation to plant height (PH) the quadratic model was verified to Simple superphosphate source with the worse at 0 kg.ha^{-1} de P_2O_5 that resulted in plants height between 2 and 2.5 cm. While the best dosage was at 57.25 kg.ha^{-1} de P_2O_5 that provided plant height up to 3.6 cm. Plants submitted dosages more than 57.25 kg.ha^{-1} showed quickly decrease of this variable (Figure 1).

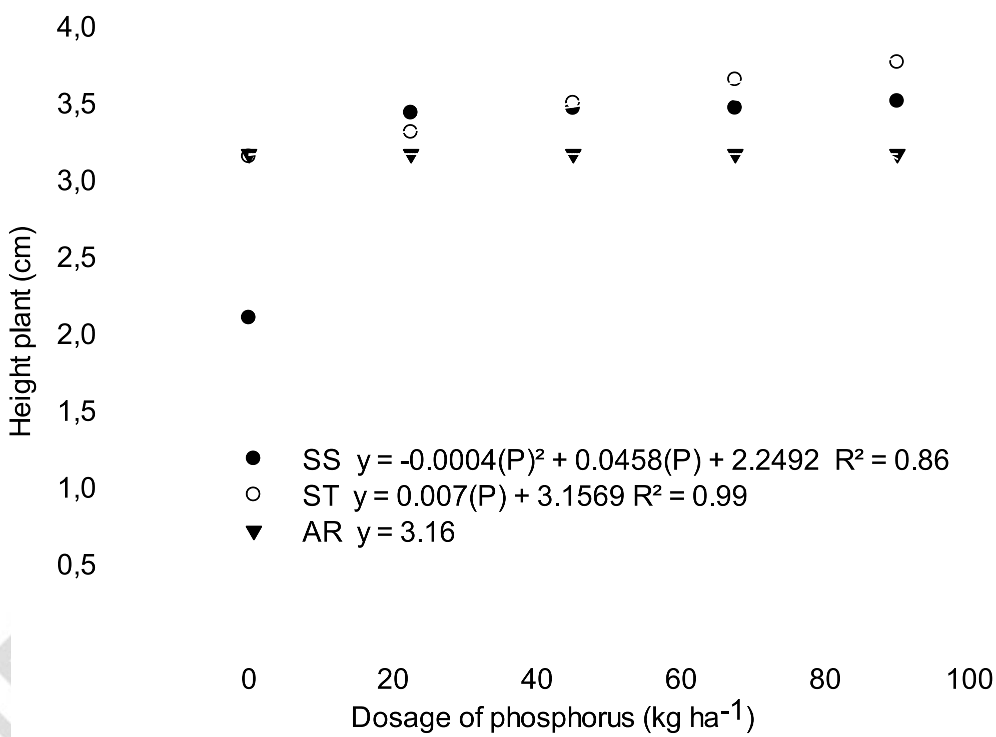

Figure 1. Height plant of young plants of pumpkins in function of dosages and sources of phosphorus

This response can be due to chemical composition of fertilizers, because the SS contain 18% soluble P_2O_5, 26% CaO and 12% S. So, this source give to soil, beyond P and

Calcium, the Sulphur, that allow the formation of agricultural plaster that may realized soil correction that results in improving of root systems [22].

Similarly [12] observed significant response to height plant with increase of dosage of Simple Superphosphate at Dystrophic Yellow Latosol in radish. The authors found an increase of 61.7% (251.32 $mg.dm^{-3}$) in height plant in comparison to plants without phosphorus supply. We found adjustment linear to Triple superphosphate that means increase of PH in different level of P_2O_5. On the other hand, we did not observe statistical difference in ARAD sources for this variable (Figure 1).

The absence of a response from the ARAD source, may be related to its main characteristic is to have slow release of P_2O_5. Therefore, its use is more frequent in perennial species such as fruit trees [23].

However, [24] argue that in recent years, the use of alternative sources, such as phosphate rocks, has increased, although this product has low solubility in water when compared to soluble phosphates. What justifies the use of this source in the present research, it is possible to have different results if there had been more research time.

The response of number of leaves (NL) was adjusted to the quadratic model, where the ideal dosage was 62.5 $kg.ha^{-1}$, obtaining 6.78 leaves per plant. For the stem diameter (SD), the linear model was adjusted that showed the increase of SD was directly proportional to the level of P_2O_5 (Figures 2A and 2B).

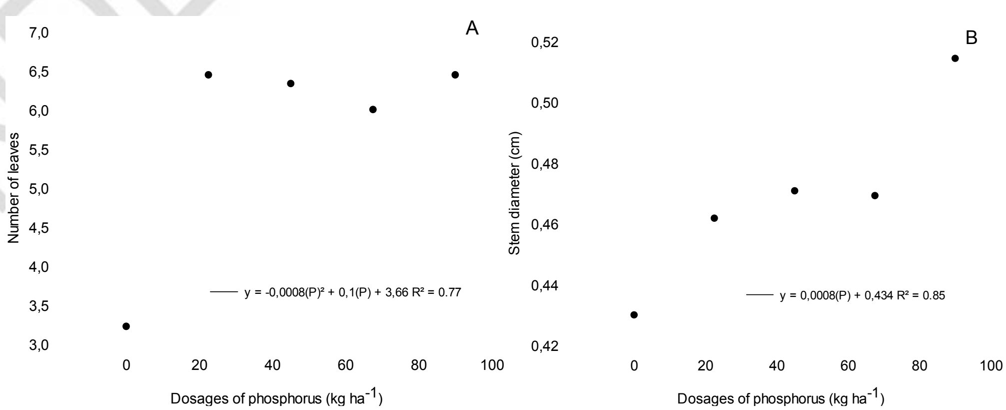

Figure 2. Number of Leaves (A) and stem diameter (B) of young plants of pumpkins in function of dosages and sources of phosphorus

The lower results observed in low doses of phosphorus can be resulted the phosphorus deficiency that affects the plant growth, because it causes less leaf emission, which reduces the leaf area, consequently, limits the capture of the solar radiation and results in lower production of photoassimilates [25].

According to [26], the low availability of P in the soil is a limiting factor for the development of the crop, because this nutrient, besides being a constituent of the nucleic acids, also has great importance in the storage and transfer of energy, being indispensable for good development of crops.

There was no significant response of the interaction of the treatments to fresh root mass and dry root mass. However, there was statistic interaction for fresh and dry aerial mass (Table 2).

Table 2. Summary table of variance analysis of the mean squares (MS) for fresh root mass (FRM), fresh aerial mass (FAM), dry root mass (DRM) e dry aerial mass (DAM) of young plants of pumpkins in function of dosages and sources of phosphorus

F.V	DF	Mean Squares			
		FRM	**FAM**	**DRM**	**DAM**
DOSAGES	4	57.31**	50.23**	0.35 ^{NS}	4.05**
SOURCES	2	16.99^{NS}	49.46**	0.08 ^{NS}	5.62**
DOSAGES*SOURCES	8	5.16^{NS}	6.92**	0.28 ^{NS}	0.60**
Error	30	6.81	1.88	0.28	0.19
CV (%)		38.86	18.70	12.19	25.61

**Significant at the 5% level of error probability, **Significant at the 1% probability level of the error and NS Not significant at the 0.05 level of probability by the F test. F.V: sources of variations; DF: degrees of freedom.*

It can be noticed that the production of fresh root mass (FRM) was influenced by the dosages of phosphorus (P_2O_5), and presented a quadratic adjustment. This results shows the absence of the phosphate fertilization had severe consequences for the development of the root system. The best result was obtained with the 56.12 $kg.ha^{-1}$ dose of P_2O_5, obtaining 8.88 g $plant^{-1}$ (Figure 3A).

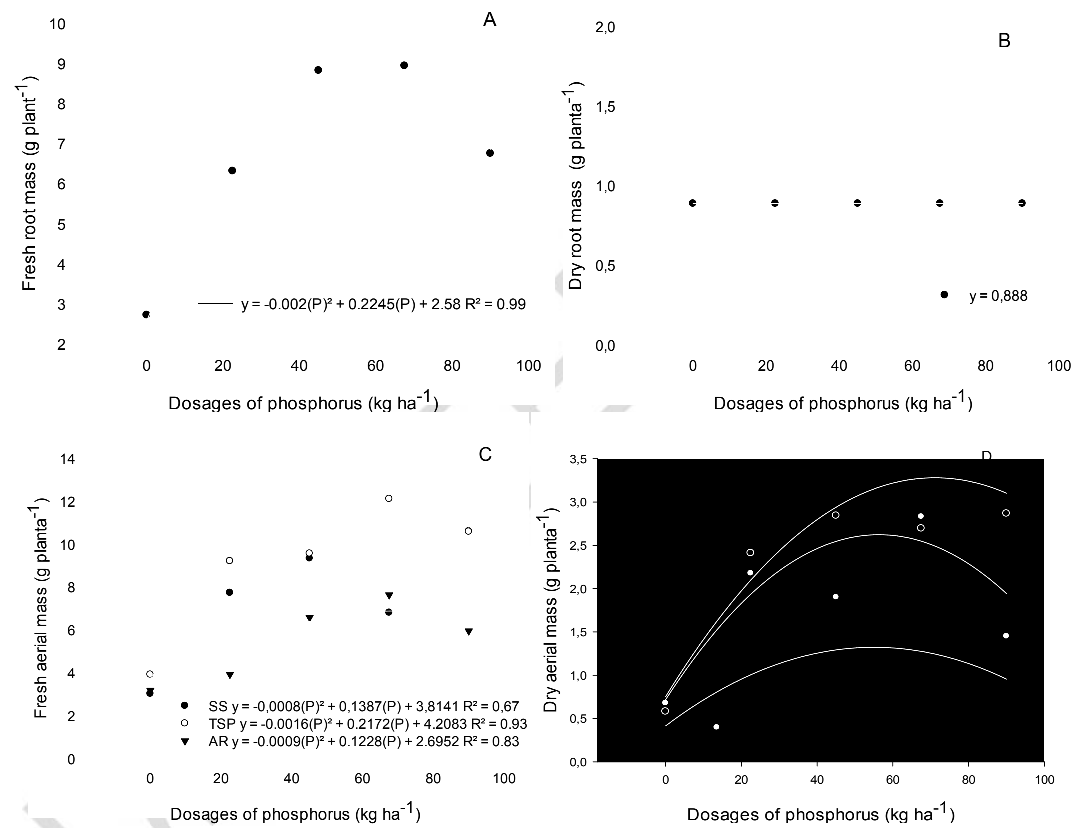

Figure 3. Fresh root mass (FRM) (A), dry root mass (DRM) (B), fresh aerial mass (FAM) (C) and dry aerial mass (DAM) (D) of young plants of pumpkins in function of dosages and sources of phosphorus.

The high decrease of fresh root mass can be related toxicity by phosphorus. According to [27], elevated concentrations of phosphorus can reduce photosynthesis due to the excessive exportation of triose-P from mitochondria to the cytosol, which prejudice the

Rubisco regeneration and, therefore, the fixation of CO_2 in the photosynthetic process. Thus, phosphorus plays an important role in plant nutrition, as it performs metabolic functions such as the synthesis of proteins and nucleic acids [28]. Ideal dosage of phosphorus favors development of the root system, absorption of water and nutrients, increasing the quality and yield of harvested fruits.

On the other hand, the dry root mass (DRM) did not show statistical difference in function of P_2O_5 levels (Figure 3B). In relation to fresh aerial mass (FAM), all sources showed adjustment quadratic in function of different dosages, but the higher response was the TSP at 67.87 kg.ha^{-1} dosage of P_2O_5. The second source with better performance was the SS, at 86.68 kg.ha^{-1} dosage of P_2O_5 and the ARAD demonstrated the worst result.

As for the dry aerial mass (DAM), it is visible that all the sources were fitted to the quadratic regression model, where again the best of them was the SS with 71.10 kg.ha^{-1} of P_2O_5, followed by TSP with 56.33 kg.ha^{-1} of P_2O_5 and finally the ARAD with 55 kg.ha^{-1} of P_2O_5 (Figure 3D).

However, for DAM the best performance was obtained by the SS source, this source has the advantage of containing sulfur in its composition which contributes directly to the plant growth. Sulfur (S) is absorbed by plants in the form of sulfate anionic, presents in organic matter, and a small proportion in the atmosphere, in the form of sulfuric gas. When there is deficiency of this secondary macronutrient, the protein synthesis is inhibited because the S is a participant of two essential amino acids (Cystine and Methionine), as a consequence the plants have a lower content of chlorophyll and less developed roots [29]. Many studies has showed the higher efficiency with TSP than natural phosphate, where the crops have more dry biomass production [30-32].

According to (Table 3), there was no significant difference between the sources of phosphorus for stem diameter (SD), fresh root mass (FRM) and dry root mass (DRM). In relation to NF, the most soluble sources (SS and ST) were better compared to ARAD.

Table 3. Tukey test for number of leaves (NL), stem diameter (SD), fresh root mass (FRM) and dry root mass (DRM) of young plants of pumpkins in function of phosphate sources

Sources of Phosphorus	NL	SD	FRM	DRM
Simple Superphosphate (SS)	6,40a	0,478a	7,03a	0,80a
Triple Supperphosphate (TSP)	6,00a	0,468a	7,57a	0,91a
Natural Phosphate of Arad (ARAD)	4,66 b	0,460a	5,52a	0,94a

** Average followed by distinct letters differs in the column (lowercase) by the Tukey test at 5% probability.*

[26] found a similar result when testing the natural reactive phosphate doses of ARAD and Triple superphosphate, and there was no significant difference for the stem diameter in sugarcane. Kano et al. [33] observed a linear increase in the number of leaves in lettuce in function of TSP dosages (0, 200, 400, 600 and 800 kg ha^{-1} of P_2O_5). In general, the fertilization with the TSP source provided a greater number of leaves, corroborating with the results obtained by [34] and [35] in lettuce.

4. CONCLUSION

Young plants of pumpkins were significantly influenced by phosphate fertilization. As the superphosphate and triple superphosphate sources provided better development and accumulation of dry matter. The natural reactive phosphate of ARAD was lower in all analyzed variables.

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