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Soil fertility and yield of 'Paluma' guava fertilized with phosphorus, cattle manure, and boron[1]

Fertilidade do solo e produtividade da goiabeira 'Paluma' adubada com fósforo, esterco bovino e boro

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HIGHLIGHTS:

Monoammonium phosphate increased the yield of 'Paluma' Guava.
Phosphorus and bovine manure contributed to the fertility of the Oxisol evaluated.
Monoammonium phosphate increased the phosphorus values of the Oxisol evaluated.

ABSTRACT: The low soil fertility associated with the lack of adequate irrigation management are factors that most limit crop production. Therefore, the study aimed to evaluate the chemical attributes of an Oxisol and the yield of 'Paluma' guava under irrigation with saline water and fertilized with phosphorus, cattle manure, and boron. The treatments were distributed in randomized blocks, with four repetitions and two plants per plot, including borders on the sides of the useful experimental area, arranged in a factorial scheme (5 × 2) + 1, referring to five phosphorus doses (0, 0.08, 0.16, 0.24 and 0.32 kg of P_2O^5 plant^{-1}), two doses of cattle manure, 0 and 30 kg per plant and an additional treatment consisting of 0.16 kg of P_2O_5 plus 30 kg of cattle manure and 1.0 g of boron, using as source the borax. In the soil, pH, phosphorus, potassium, calcium, magnesium, and the cation exchange capacity were evaluated in the 0-20 cm and 20-40 cm layers. In plants, the average yield per hectare in two harvests was estimated. The pH decreased with phosphorus doses without cattle manure and in the treatment with boron in the 20-40 cm layer. The cation exchange capacity increased with the application of phosphorus doses associated with manure and decreased in both soil layers with boron. The macronutrients evaluated were not influenced by boron. Phosphorus doses associated with cattle manure increased yield, exceeding the average of 50 t ha^{-1} year^{-1} determined for 'Paluma' guava. In contrast, boron did not increased the yield.

Key words: *Psidium guajava*, monoammonium phosphate, organic matter, nutrients

RESUMO: A baixa fertilidade do solo associada à falta de manejo adequado da irrigação são fatores que mais limitam a produção das culturas. Diante disso, objetivou-se avaliar os atributos químicos de um Oxisol e a produtividade da goiabeira 'Paluma' sob irrigação com água salina e adubada com fósforo, esterco bovino e boro. Os tratamentos foram distribuídos em blocos ao acaso, com quatro repetições e duas plantas por parcela, incluindo bordaduras nas laterais da área útil experimental, utilizando um esquema fatorial de (5 × 2) + 1, referentes a cinco doses de fósforo (0, 0.08, 0.16, 0.24 e 0.32 kg de P_2O_5 planta^{-1}), duas doses de esterco bovino, 0 e 30 kg por planta e um tratamento adicional composto por 0.16 kg de P_2O_5 mais 30 kg de esterco bovino e 1.0 g de boro, utilizando como fonte o bórax. No solo avaliaram-se pH, fósforo, potássio, cálcio, magnésio e a capacidade de troca catiônica nas camadas de 0-20 cm e de 20-40 cm. Nas plantas, estimou-se a produtividade média por hectare em duas safras. O pH diminuiu com as doses de fósforo sem esterco bovino e no tratamento com boro na camada de 20-40 cm. A capacidade de troca catiônica aumentou com aplicação das doses de fósforo associadas ao esterco e diminuiu nas duas camadas do solo com a presença do boro. Os macronutrientes avaliados não foram influenciados pelo boro. As doses de fósforo associadas ao esterco bovino aumentaram a produtividade superando a média de 50 t ha^{-1} ano^{-1} determinada para a goiabeira 'Paluma', enquanto que o boro não aumentou a produtividade.

Palavras-chave: *Psidium guajava*, fosfato monoamônico, matéria orgânica, nutrientes

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Introduction

Brazilian soils, in general, have low fertility, either due to formation factors, which cause significant losses of nutrients throughout the profile or due to continuous cultivation resulting from the production of annual and perennial crops, making fertilization necessary for the supply of chemical elements essential to plant growth and production. For this reason, several researchers have been looking for information on sources, doses, and the best way to apply fertilizers and their correlation with increased yield (França et al., 2017).

Phosphorus and boron are nutrients that participate in all metabolic processes that involve energy expenditure, from the absorption of nutrients to different organs' formation (Guimarães et al., 2012).

Micronutrients, such as boron, play a fundamental role in the production of crops, they are essential to plant development, and when provided at inadequate levels, they retard plant growth, which can cause imbalances in plant metabolism (Santana et al., 2016).

'Paluma' guava is a perennial crop in the Myrtaceae family. The fruits have a sweet, acidified flavor with a pleasant aroma, the main reason for their great variety of products, uses, and forms of consumption (Ferreira et al., 2019). The Southeast and Northeast regions of Brazil stand out as the largest guava producers in the country, being responsible, respectively, for 47.40 and 39.9% of national production, approximately 359.30 thousand t of fruit in a harvested area of 15.8 thousand hectares (Bezerra et al., 2018)

Thus, this experiment aimed to evaluate the effects of phosphorus doses in the absence and presence of cattle manure and boron on soil fertility and on the yield of 'Paluma' guava under irrigation with saline water.

Material and Methods

The experiment was carried out from March 2017 to August 2018, in Cuité, PB, under the coordinates 06° 27' 42.66" S and 36° 09' 52.53" W, with altitude of 665 m, located in the central-west region of the State of Paraíba, Brazil. The climate of the region is Bsh-Köppen, with an average rainfall of 800 mm. The average annual temperature is around 25 °C and the air relative humidity around 75%. The soil of the experimental area is an Oxisol, with a sandy-clay texture. Before carrying out the experiment, soil samples were collected under the plants' canopy to evaluate chemical characteristics (Table 1). Physically, the soil presented in the 0-20 cm layer, 532 g kg^{-1} of sand, 91 g kg^{-1} of silt, 377 g kg^{-1} of clay, and soil bulk density of 1.72 g cm^{-3}.

The experiment was conducted in a guava orchard of the 'Paluma' cultivar, with four years of age, with a spacing of 6 x 6 m. The treatments were distributed in randomized blocks, with four repetitions and two plants per plot, including borders on the sides of the useful experimental area, arranged in a factorial scheme (5 x 2) + 1, referring to five phosphorus doses (0, 0.08, 0.16, 0.24 and 0.32 kg of P_2O_5 $plant^{-1}$), two doses of cattle manure, 0 and 30 kg per plant and an additional treatment consisting of 0.16 kg of P_2O_5 plus 30 kg of cattle manure and 1.0 g of boron, using as source the borax ($Na_2B_4O_7.10H_2O$).

As a phosphorus source, monoammonium phosphate ($NH_4H_2PO_4$) was used. The manure used was from cattle origin, with the following contents of macronutrients (g kg^{-1}): 10.24 of N; 3.36 of P; 13.95 of K; 41.41 of Ca; 9.2 of Mg; and 36.22 of S, and micronutrient (mg kg^{-1}): 350.32 of B; 15.50 of Cu; 5173.12 of Fe; 159.53 of Mn; and 126.78 of Zn. The boron used was applied only in the additional treatment, right after the fruiting pruning. The plants were subjected to water stress for 30 days, and fruiting pruning was performed according to the methodology adopted by Malta et al. (2018).

For soil correction, dolomitic lime was used (PRNT = 64%, CaO = 28%, and MgO = 14%), aiming to correct acidity, supply Ca^{2+} and Mg^{2+}, and increase the base saturation value up to 70% (Souza et al., 2009). The lime was distributed under the canopy projection and incorporated at about 15 cm by the method of soil scarification.

250 g of N and 120 g K2O per plant were applied, using urea and potassium chloride as the source. The fertilizers used were applied 15 days after pruning and liming, as well as limestone, were distributed under the canopy projection and incorporated by chiseling at about 15 cm, taking care not to damage the root system of the plants.

Irrigation was performed daily using saline water taken from a deep well, with EC (dS m^{-1} at 25 °C) of 2.28 and SAR (mmol $L^{-1})^{1/2}$ of 16.15, classified as C_4S_4. The water was distributed by a micro-sprinkler irrigation system, with a flow rate of 70 L h^{-1}, applying an irrigation depth of 6.25 mm or 43.75 L $plant^{-1}$ day^{-1}, leaving the system on for 37.5 min, to meet the water requirements of the crop, with the demand around 60 m^3 ha^{-1} day^{-1} (Nunes et al., 2014).

In the second harvest, with the aid of the Dutch auger, soil samples were collected in 0-20 and 20-40 cm soil layers, which were air-dried, sieved in a 2.0 mm sieve and determined the values of pH, P, K, Ca, Mg, and CEC, according to the methodology adopted by Aguiar & Ferreira (2014). To estimate the yield, the fruits were harvested daily and weighed on a Filizola digital-CS15 scale with a precision of 5 g. The yield was estimated according to the spacing between plants and the production per plant obtained.

Table 1. Chemical characteristics of the soil in the 0-20 and 20-40 cm layers before the experiment

Layer (cm)	pH	P	K	S	Ca	Mg	Na	Al	H+Al
		($mg\ dm^{-3}$)			($cmol_c\ dm^{-3}$)				
0-20	4.7	16.76	126.4	9.37	0.26	0.78	1.87	0.1	2.33
20-40	4.3	9.79	106.7	6.90	0.22	0.68	1.84	0.1	1.60
	SB	CEC	B	Cu	Fe	Mn	Zn	M.O	BS
	($cmol_c\ dm^{-3}$)		($mg\ dm^{-3}$)					($g\ kg^{-1}$)	(%)
0-20	3.23	5.56	0.30	0.03	4.61	1.82	0.37	10.32	58.15
20-40	3.01	4.61	0.72	0.05	22.09	5.25	0.48	7.19	65.29

SB – Sum of bases = ($Na^+ + K^+ + Ca^{2+} + Mg^{2+}$); CEC – Cation exchange capacity = SB + ($H^+ + Al^{3+}$); M.O – Organic matter; BS – Base saturation

The data were submitted to analysis of variance, considering the depth as a repeated measure in space. The means from the fertilization with cattle manure and soil depths were compared using the F-test and the phosphorus doses by polynomial regression. The additional treatment results were evaluated by the contrast of means between the additional treatment values and the values without boron. The R software was used for statistical analysis.

Results and Discussion

The soil pH was influenced by the interaction of cattle manure x soil layer and boron dose x soil layer, at $p \leq 0.01$ and $p \leq 0.05$, respectively. When comparing the mean of the additional treatment, it was found that in the surface layer of the soil (0-20 cm), the pH values did not differ, presenting averages equal to 6.4 for the soil with only 0.16 kg of P_2O_5 + 30 kg of cattle manure per plant and the additional treatment (1 g boron + 0.16 kg P_2O_5 + 30 kg manure per plant). In the deepest layer of the soil (20-40 cm), the average was higher in the soil without boron application, with a pH of 6.50 compared to the value of 5.83 for the additional treatment (Table 2).

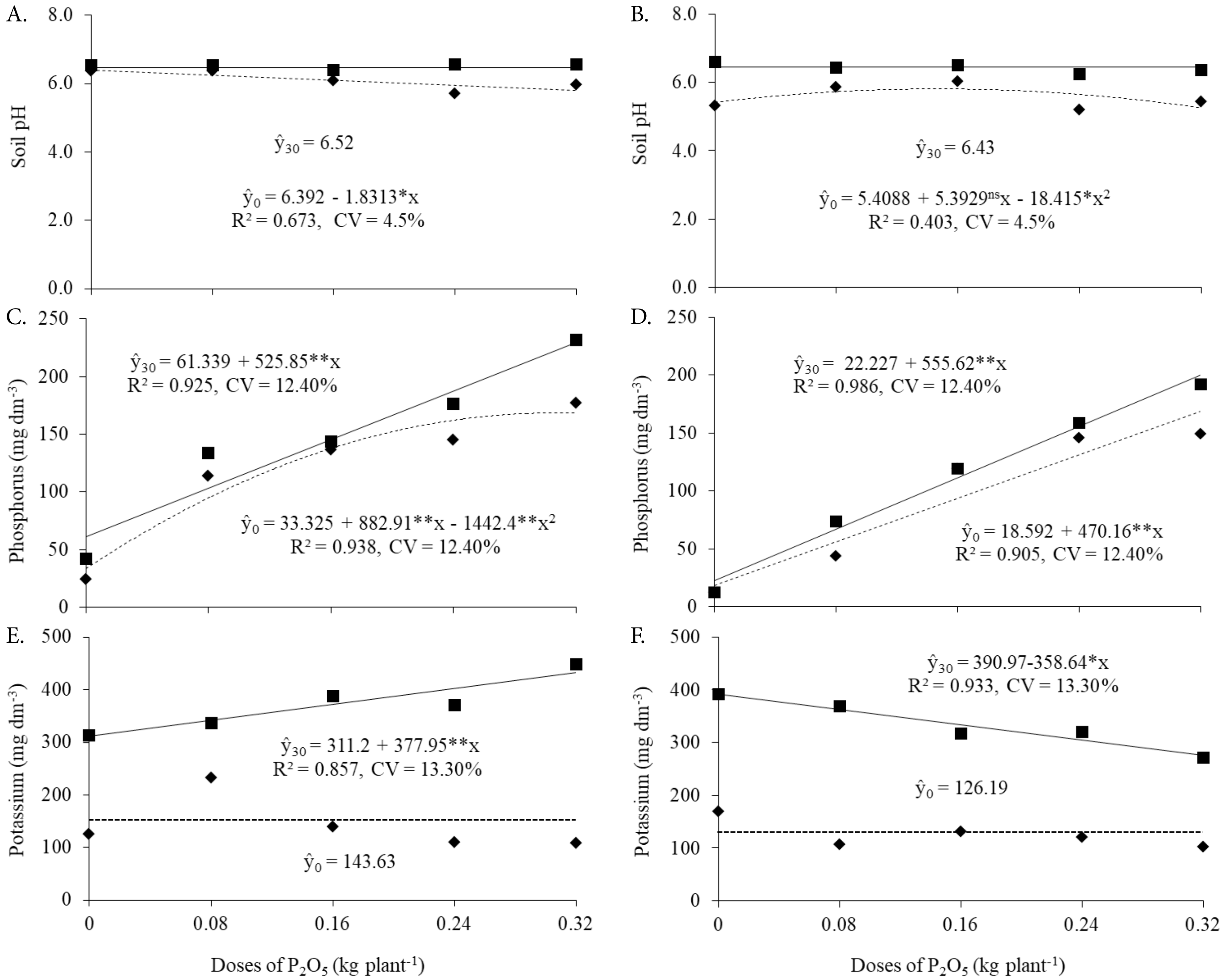
Table 2. Average values of pH and cation exchange capacity (CEC), obtained in the soil with the application of additional treatment (1.0 g boron + 0.16 kg P_2O_5 + 30 kg cattle manure per plant), grown with 'Paluma' guava

Soil layer (cm)	g of B plant^{-1}	pH	CEC (cmol$_c$ dm^{-3})
0-20	0.0	6.40 a	9.58 a
	1.0	6.40 a	8.38 b
20-40	0.0	6.50 a	9.17 a
	1.0	5.83 b	7.87 b

Means followed by the same letters in the columns do not differ by the F-test at $p \leq 0.05$

The pH in the deepest layers is generally acidic (Caetano & Carvalho, 2006), and probably boron has not contributed to this reduction, as it is a very weak acid. The pH and the concentrations of phosphorus and potassium responded to doses of P_2O_5 associated with cattle manure (Figures 1A to F).

In the 0-20 cm layer (Figure 1A), in the soil without cattle manure, the pH values decreased linearly as a function of phosphorus doses, decreasing from 6.39 in the lowest dose to 5.80 in the highest dose of applied fertilizer. In the soil with the cattle manure application, the data did not fit any regression model, represented by the average value of 6.52.



ns,**,* - Non significant and significant at $p \leq 0.01$ and $p \leq 0.05$ by F-test, respectively

Figure 1. PH values (A and B), phosphorus (C and D) and potassium concentrations (E and F) in 0-20 and 20-40 cm soil layers, in function of phosphorus doses without (---$\hat{y}_0$) and with (—$\hat{y}_{30}$) cattle manure, in soil cultivated with 'Paluma' guava

In the 20-40 cm layer (Figure 1B), in the soil without cattle manure, the data adjusted to the quadratic regression model, increasing up to 5.80 in the estimated dose of 0.1464 kg plant^{-1} of P_2O_5. In the presence of cattle manure, the values did not adjust to any regression model, which is represented by the average value of 6.43 (Figure 1B).

In both soil layers, there was a higher pH in treatments with cattle manure, directly favoring the reduction of soil acidity. These results corroborate those obtained by Malta et al. (2019), studying the physical and chemical attributes of an Oxisol cultivated with the Morada Nova soursop cultivar, under organic and mineral fertilization, in which the soils that received organic fertilization showed an increase in pH, attributing to the increase in the contents of organic matter, due to its ability to adsorb H^+ ions.

Lisboa et al. (2017), applying MAP in an Oxisol, observed significant reduction in soil pH in the treatments that received the fertilizer, attributing the presence of nitrogen in the ammoniacal form from the MAP, which in its oxidation dissociates, releasing H + ions to the solution of the ground.

Phosphorus concentrations responded significantly to the interaction of phosphorus x cattle manure and phosphorus x soil layer at $p \leq 0.05$ and $p \leq 0.01$, respectively. There was no significant difference between the mean from the treatment without boron application (0.16 kg P_2O_5 + 30 kg of cattle manure per plant) and the mean from the additional treatment (1 g boron + 0.16 kg P_2O_5 + 30 kg of cattle manure per plant) with results of 131.60 and 148.77 mg dm^{-3}, respectively (Table 3).

Based on Figure 1C, the phosphorus concentration was higher in the 0-20 cm layer, increasing linearly in function of the doses of P_2O_5 applied. The data adjusted to the quadratic polynomial regression model, reaching maximum value of 168.43 mg dm^{-3} at the dose of 0.3061 kg of P_2O_5 per plant^{-1} in the soil without application of cattle manure. In the soil with the use of cattle manure, phosphorus concentrations increased linearly in function of the doses of P applied, reaching maximum value of 229.61 mg dm^{-3} at the maximum dose of 0.32 kg of P_2O_5 plant^{-1}.

In the subsurface layer (Figure 1D), phosphorus concentrations increased linearly with increasing P_2O_5 doses. In the absence of cattle manure, they were raised from 18.59 mg dm^{-3} to values up to 169.04 mg dm^{-3} at the highest phosphorus dose applied to the soil. With the cattle manure application, the values increased from 22.22 to 200.02 mg dm^{-3} at the maximum P_2O_5 dose of 0.32 kg plant^{-1}.

When studying phosphorus concentrations after application of doses of monoammonium phosphate of slow-release (KimCoat), with treatments without application of P and increasing doses of 50, 100, 200, and 400 mg dm^{-3} P_2O_5, Machado et al. (2012) observed increase in phosphorus in the soil, especially in Oxisol, with greater availability of the nutrient the higher the dose applied. Oliveira et al. (2017), when studying the localized application of phosphate fertilizers, such as triple superphosphate (TSF), simple superphosphate (SSF), diammonium phosphate (DAP), and monoammonium phosphate (MAP) at a dose of 200 mg kg^{-1} P (916 kg ha^{-1} P_2O_5), besides the control treatment without the addition of P, observed significant increases in P in the soil, especially in the treatment with the application of MAP, when compared to the others, reaching values of 73 against 68 and 66 mg dm^{-3} of DAP and TSF, respectively.

Table 3. Average concentrations of phosphorus (P), potassium (K^+), calcium (Ca^{2+}), magnesium (Mg^{2+}), and average yield value obtained in the soil with the application of additional treatment (1.0 g boron + 0.16 kg P_2O_5 + 30 kg cattle manure per plant), grown with 'Paluma' guava

g of B plant^{-1}	P	K^+	Ca^{2+}	Mg^{2+}	Yield
	(mg dm^{-3})		(cmol$_c$ dm^{-3})		(t ha^{-1})
0.0	131.60 a	352.23 a	2.56 a	3.19 a	33.56 a
1.0	148.77 a	374.85 a	2.28 a	2.25 a	33.57 a

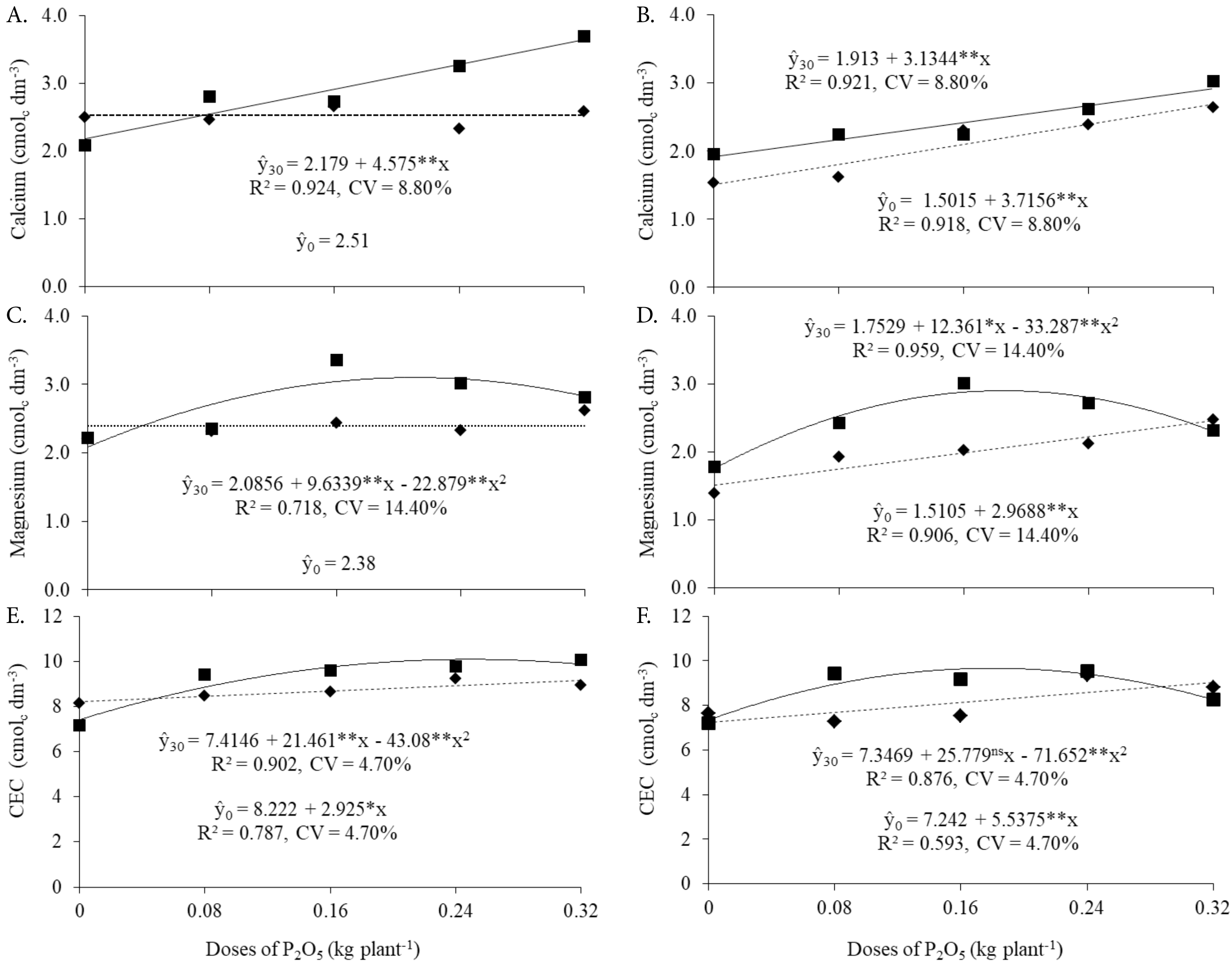
Means followed by the same letters in the columns do not differ by the F-test at $p \leq 0.05$

The highest concentrations of P were observed in the presence of cattle manure since the availability of P in the soil, besides being related to its pH, also depends on the amount of organic matter. The application of organic matter favors the formation of metal-organic complexes, increasing the solubility of iron and aluminum phosphates, reducing the adsorption of the phosphate anion in the solid phase of the soil (Janegitz et al., 2015). Potassium concentrations (Figure 1) were influenced by the interaction of phosphorus x cattle manure x soil layer at $p \leq 0.01$. They did not respond to the interaction of the boron dose x soil layer. In the additional treatment, there was no statistically significant difference between the mean of the treatment without boron application (0.16 kg P_2O_5 + 30 kg of manure per plant) and the mean of the additional treatment (1 g of boron + 0.16 kg P_2O_5 + 30 kg of manure. per plant), with results of 352.23 and 374.85 mg dm^{-3}, respectively (Table 3).

In soil without cattle manure, the potassium concentrations did not fit any regression model; it is represented by the mean values of 143.63 and 126.19 mg dm^{-3} in the 0-20 and 20-40 cm layers, respectively (Figures 1E and F). In both soil layers, the data adjusted to the linear regression model in the presence of cattle manure. In the 0-20 cm soil layer, the data raised from 311.20 mg dm^{-3} at the lowest dose of phosphorus up to 432.14 mg dm^{-3} at the maximum dose of applied fertilizer (Figure 1E). Whereas in the 20-40 cm layer (Figure 1F), the potassium values decreased from 390.97 to 276.20 mg dm^{-3} in the highest dose of P_2O_5. The increase in the K concentration in the upper layer of the soil when P was associated with manure was probably due to the large number of negative charges that were generated by the carboxylic and phenolic groups from cattle manure and phosphate fertilizer, mainly the primary orthophosphate $H_2PO_4^-$, which contains negative charges (Novais et al., 2007). Possibly, in the soil without cattle manure, the pH has influenced the reduction of potassium, due to the reduction in the number of surface loads, mainly negative, thus favoring the losses of potassium from the solution by leaching, also emphasizing that the soil was collected in the rainy season, with significant amounts of water percolating into the system (Santos et al., 2012).

Increases in potassium through the application of cattle manure have also been evidenced by Malta et al. (2019) when evaluating the chemical properties of an Oxisol cultivated with the Morada Nova soursop cultivar.

Calcium concentrations were influenced by the interaction of phosphorus x cattle manure x soil layer at $p \leq 0.05$ (Figure 2). There was no significant difference between the mean the



ns,**, * - Non significant and significant at $p \leq 0.01$ and $p \leq 0.05$ by F-test, respectively

Figure 2. Concentrations of calcium (A and B), magnesium (C and D) and cation exchange capacity (E and F) in soil layers of 0-20 and 20-40 cm, in fuction of the phosphorus doses without (---$\hat{y}_0$) and with (—$\hat{y}_{30}$) cattle manure, in soil cultivated with 'Paluma' guava

additional treatment and the mean without boron application (0.16 kg P_2O_5 + 30 kg of manure per plant), with results of 2.28 and 2.56 $cmol_c$ dm^{-3}, respectively (Table 3). In the 0-20 cm layer, when evaluated in the presence of manure, the calcium concentration increased linearly, from 2.18 to 3.64 $cmol_c$ dm^{-3} at the maximum dose of 0.32 kg of P_2O_5 per $plant^{-1}$. In the absence of cattle manure, the data did not fit the regression model and was represented by the mean value of 2.51 $cmol_c$ dm^{-3} (Figure 2A).

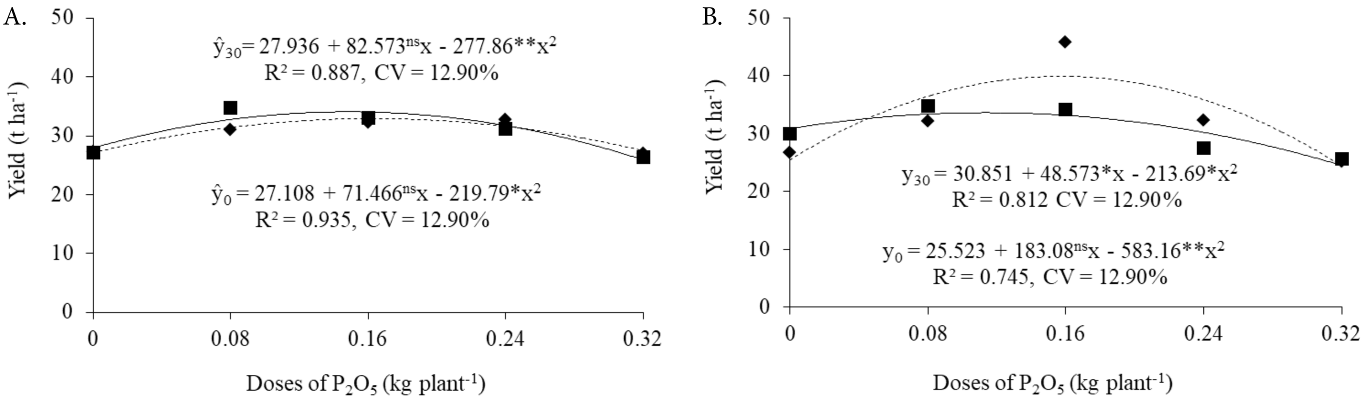
In the 20-40 cm layer, both for soil without and with cattle manure, calcium levels increased linearly, with superiority registered in the presence of cattle manure, with an increase from 1.91 $cmol_c$ dm^{-3}, in the minimum dose, to 2.92 $cmol_c$ dm^{-3} at the highest dose of phosphorus applied. In the soil without cattle manure, calcium concentrations were increased from 1.50 to 2.69 $cmol_c$ dm^{-3} at the dose of 0.32 kg of P_2O_5 $plant^{-1}$ (Figure 2B).

Comparing with the results that the soil had before applying the treatments (Table 1), with concentrations of 0.26 and 0.22 $cmol_c$ dm^{-3} of Ca in the soil layers of 0-20 and 20-40 cm in the canopy projection, respectively, it is noticed that the calcium concentrations increased, but with a lower proportion in the deeper layer. The lower concentrations of calcium in the deepest layer of the soil can be attributed to the slow mobility of the element in the soil, which characterizes low dynamics between the layers in the profile (Costa et al., 2009).

Magnesium concentrations were influenced by the phosphorus x cattle manure interaction at $p \leq 0.05$ (Figure 2). The average from the treatment without boron application (0.16 kg P_2O_5 + 30 kg manure per plant) and the average from the additional treatment (1 g boron + 0.16 kg P_2O_5 + 30 kg cattle manure per plant) did not differ, with averages of 3.19 and 2.25 $cmol_c$ dm^{-3}, respectively (Table 3).

When evaluated in the soil with cattle manure in the 0-20 cm soil layer, the magnesium values were adjusted to the quadratic polynomial regression model, with a maximum value of 3.10 $cmol_c$ dm^{-3} at the maximum physical efficiency dose of 0.2105 kg $plant^{-1}$ of P_2O_5. When evaluated in the soil without the presence of cattle manure, there was no adjustment, being represented by the average value of 2.38 $cmol_c$ dm^{-3} of magnesium (Figure 2C).

In the 20-40 cm layer, in the soil with and without cattle manure, magnesium concentrations increased with



ns,**, * - Non significant and significant at $p \leq 0.01$ and $p \leq 0.05$ by F-test, respectively

Figure 3. Yield of 'Paluma' guava in function of the phosphorus doses in the soil without (---$\hat{y}_0$) and with (—$\hat{y}_{30}$) cattle manure, in two evaluated harvests (A and B)

phosphorus doses, with superiority in the presence of cattle manure, increasing quadratically up to 2.90 $cmol_c\ dm^{-3}$ in the dose of 0.1857 kg of P_2O_5 $plant^{-1}$. While in the absence of organic matter, the values increased linearly, from 1.51 $cmol_c\ dm^{-3}$ in the lowest phosphorus dose to values up to 2.46 $cmol_c\ dm^{-3}$ in the dose of 0.32 kg of P_2O_5 $plant^{-1}$ (Figure 2D).

Lisboa et al. (2017), applying MAP in an Oxisol, observed a significant effect of the tested doses of P in the increase of Ca, Mg, and K cations in the soil, attributing to the interactive effects existing between the elements.

The cation exchange capacity (Figure 2) responded significantly to the interaction of phosphorus x cattle manure x soil layer and the interaction boron x soil layer at $p \leq 0.01$ and $p \leq 0.05$, respectively. Comparing the average of the additional treatment (1.0 g boron + 0.16 kg P_2O_5 + 30 kg of cattle manure per plant) with the average of the treatment without application of boron (0.16 kg P_2O_5 + 30 kg of cattle manure per plant), there were significant differences, with values 9.58 and 8.38 $cmol_c\ dm^{-3}$ in the 0-20 cm layer, and 9.17 and 7.87 $cmol_c\ dm^{-3}$ in the 20-40 cm layer, for the soil without and with additional treatment, respectively (Table 2).

In the 0-20 cm layer, the CEC values of the soil when in the presence of cattle manure, increased quadratically depending on the phosphorus doses applied, with a maximum value of 10.08 $cmol_c\ dm^{-3}$ at the dose of 0.2491 kg of P_2O_5 $plant^{-1}$. When evaluated in the soil without cattle manure, the soil CEC values increased linearly in function of the phosphorus doses, increased from 8.22 to 9.16 $cmol_c\ dm^{-3}$ at the highest dose of P_2O_5 applied to the soil (Figure 2E).

In the 20-40 cm layer with the application of cattle manure, the CEC values of the soil increased quadratically in function of to the applied doses, with a maximum value of 9.66 $cmol_c\ dm^{-3}$ obtained in the dose of 0.1799 kg of P_2O_5 $plant^{-1}$. In the absence of cattle manure, soil CEC values increased linearly, reaching a maximum value of 9.01 $cmol_c\ dm^{-3}$ at a dose of 0.32 kg of P_2O_5 $plant^{-1}$ (Figure 2F).

The contribution of cattle manure in increasing the CEC verified in this experiment possibly can be attributed to the dissociation of the carboxylic and phenolic groups present in the humic substances, with strong interactions between cations and anions, present in the solution, increasing the soil CEC, thus helping to retain cations, decreasing significant leachate losses, reducing the need for chemical fertilization (Silva & Mendonça, 2007).

Yield responded significantly to the interaction of phosphorus x harvest and phosphorus x cattle manure at $p \leq 0.05$. When comparing the average from the additional treatment (1.0 g boron + 0.16 kg P_2O_5 + 30 kg of cattle manure per plant) with the average from the treatment without application of boron (0.16 kg P_2O_5 + 30 kg of cattle manure per plant), there were no significant differences, with average values of 33.56 and 33.57 t ha^{-1}, for soil without and with additional treatment, respectively.

When cattle manure was applied in the first harvest evaluated, the yield reached 34.07 t ha^{-1} at the dose of 0.1486 kg of P_2O_5 $plant^{-1}$. The highest yield value (32.91 t ha^{-1}) was obtained in the soil without cattle manure at the dose of 0.1626 kg of P_2O_5 $plant^{-1}$ (Figure 3A). In the second harvest, the yield was higher in the soil without cattle manure, reaching the value of 39.89 t ha^{-1} in the dose of 0.1570 kg of P_2O_5 $plant^{-1}$. With the application of cattle manure, the maximum yield was 33.61 t ha^{-1} at the phosphorus dose of 0.1137 kg $plant^{-1}$ of P_2O_5 (Figure 3B).

Comparing the average results, they surpassed the 19.33 - 21.25 t ha^{-1} found by Malta et al. (2018) and the 25 - 34 t ha^{-1} obtained by Cavalcante et al. (2019), evaluating organomineral fertilization in 'Paluma' guava in an Oxisol and an Entisol, respectively.

Conclusions

1. In the absence of cattle manure, the soil pH decreases with the application of monoammonium phosphate doses.

2. The concentrations of phosphorus, potassium, calcium, magnesium, and the cation exchange capacity increased with the application of monoammonium phosphate doses associated with cattle manure.

3. Boron decreased the pH in the 20-40 cm soil layer, and the cation exchange capacity in the two soil layers evaluated.

4. In the absence of cattle manure, the highest yield (39.89 t ha^{-1}) was obtained in the second harvest with the dose of 0.1570 kg P_2O_5 $plant^{-1}$.

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