

DOSES OF PHOSPHORUS ASSOCIATED WITH NITROGEN ON DEVELOPMENT OF COFFEE SEEDLINGS

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ABSTRACT: A greater supply of nitrogen in the substrate using organic compost for coffee (*Coffea arabica* L.) seedlings can increase the effects of phosphorus in the plant and thereby promoting growth of biomass, enhancing the growth of plants when they are transplanted into the growing environment. The objective was evaluate the effect of phosphorus levels higher than those usually recommended in the absence and presence of nitrogen supplementation in the preparation of substrate containing organic compound to produce coffee seedlings grown in bags. The experiment was installed at a nursery in Araxá city, Minas Gerais State, Brazil in may 2011, using substrate containing 70 % of soil samples and 30 % of cattle manure, with the addition of 1 kg m⁻³ of potassium chloride and 1 kg m⁻³ of dolomitic lime. We used coffee seedlings of Catuaí Vermelho cultivar IAC 144 grown in polyethylene bags (1694 cm³). The experiment was installed in a completely randomized design with four replicates and 12 treatments in a 6 x 2 factorial scheme, with six levels of phosphorus (P): 0, 109, 218, 436, 872 and 1308 mg dm⁻³, as triple superphosphate; and two levels of nitrogen (N): absence and 100 mg dm⁻³ in the form of urea. The biometric variables, seedlings quality indexes, soil P concentration as well as accumulation of N and P by plants were determined at 180 days after sowing. Through regression analysis to conclude that the application of phosphorus in the substrate enhanced the P concentration in soil and plant, reflecting in the growth and dry matter production of coffee seedlings, especially in the presence of nitrogen. The highest tested dose of phosphorus (1308 mg dm⁻³) is the most appropriate dose for the production of coffee seedlings. The addition of nitrogen to the substrate containing cattle manure is important to supply the need of this nutrient in the seedlings.

Index terms: *Coffea arabica* L., phosphorus fertilization, Dickson index, seedling quality.

DOSES DE FÓSFORO ASSOCIADAS AO NITROGÊNIO NO DESENVOLVIMENTO DE MUDAS DE CAFEIEIRO

RESUMO: O aumento do suprimento de nitrogênio, na composição do substrato que utiliza composto orgânico, para produção de mudas de cafeeiro pode potencializar os efeitos da adubação fosfatada na planta. Objetivou-se avaliar o efeito de doses de fósforo maiores que as usualmente recomendadas, na ausência e na presença de suplementação nitrogenada no preparo de substrato contendo composto orgânico, para produção de mudas de cafeeiro cultivadas em sacolas. O experimento foi instalado em viveiro telado no município de Araxá, MG, utilizando substrato contendo 70% de amostras de solo e 30% de esterco bovino, com adição de 1 kg m⁻³ de cloreto de potássio e 1 kg m⁻³ de calcário dolomítico. Utilizaram-se mudas de café cultivar Catuaí Vermelho IAC 144, cultivadas em sacolas de polietileno (1694 cm³). Os tratamentos foram em arranjo fatorial 6x2, tendo seis doses de fósforo: 0; 109; 218; 436; 872 e 1308 mg dm⁻³ de P, na forma de superfosfato triplo, na ausência e na presença de nitrogênio (100 mg dm⁻³), na forma de ureia. O delineamento experimental utilizado foi inteiramente casualizado, com quatro repetições. Foram determinadas, aos 180 dias após a semeadura, as variáveis biométricas, índices de qualidade de mudas, teor de P no solo e o acúmulo de P e N pelas mudas. Através da análise de regressão, conclui-se que a aplicação de fósforo ao substrato aumenta a concentração de P no solo e na planta, refletindo em maior crescimento e matéria seca produzida, especialmente na presença da adubação nitrogenada. A maior dose de fósforo testada (1308 mg dm⁻³) é a mais adequada para a produção de mudas de café. A adição de nitrogênio ao substrato, que contém esterco de gado, é importante para suprir a necessidade desse nutriente nas mudas.

Termos para indexação: *Coffea arabica* L., fertilizante fosfatado, índice de qualidade de Dickson, qualidade de muda.

1 INTRODUCTION

The substrates for production of coffee (*Coffea arabica* L.) seedlings are usually made up of soil samples supplemented with organic compounds and mineral fertilizers. The proportion

and quality of each one of them provides nutrient availability and favors adequate physical conditions for the plant (DIAS et al., 2009). One of the important nutrients for coffee is phosphorus, because it causes an increase in root development and plant vigor to ensure the formation of crops

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with high productivity and low rates of replanting.

However, phosphorous deficiency causes immediate disturbances in metabolism and development of plants (LAWLOR; CORNIC, 2002). Various studies indicate that the highest development of coffee seedlings occurs when using doses of 0.86 to 1.0 kg m⁻³ P₂O₅ (CUNHA et al., 2002). Increased availability of soil phosphorus in relation to the recommended promotes greater availability of energy as carbohydrate levels, reflecting in a best plant growth (SILVA et al., 2010).

The beneficial effect of phosphorus in plant development depends on the amount of nitrogen available to the plant, besides the suitable dose of this nutrient (PRADO, 2008). Normally in the production of coffee plants a simple organic compound, traditionally cattle manure, is used as a nitrogen source (CUNHA et al., 2006), so the quantities of N supplied may not be sufficient for a good response by the coffee, especially when using higher doses of phosphorus, since the beneficial effects of N in increasing the efficiency of fertilization are known (PRADO, 2008). In this sense, using 56 to 60 mg N dm⁻³ of the substrate for coffee seedlings production of Catuaí Vermelho cultivar gives greater dry matter in stems and leaves, in addition to increasing the leaf area (CARVALHO et al., 1978). Therefore, the objective was evaluate the effect of phosphorus levels higher than those usually recommended in the absence and presence of nitrogen supplementation in the preparation of substrate containing organic compound to produce coffee seedlings grown in bags.

2 MATERIALS AND METHODS

The experiment was conducted in the nursery at the Experimental Farm of Araxá Agriculture Cooperative, in the municipality of Araxá, Minas Gerais State, Brazil, 19°33'21"S and 46°58'08" W, from May to December 2011. The average annual temperature is 20.4 °C.

The substrate was prepared using 70 % of soil sample, 30 % of cattle manure, 1 kg m⁻³ of potassium chloride and 1 kg m⁻³ was added, as indicated by Matiello et al. (2010). The cattle manure is the most appropriate compound for the formation of coffee seedlings (ALMEIDA et al., 2011). We used samples from an Oxisol (EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - EMBRAPA, 2006), removed from a layer of 0.1 to 0.2 m depth and then sieved using 5 mm mesh. Subsequently, we made a

mixture of soil and manure and held sampling and chemical analyses of the substrate, according to the methods proposed by Raji et al. (2001), getting the following results: pH (CaCl₂) = 6.3; M.O. = 28 g dm⁻³; P-resina = 8 mg dm⁻³; K⁺ = 14.3 mmol_c dm⁻³; Mg⁺² = 11 mmol_c dm⁻³; Ca⁺² = 30 mmol_c dm⁻³; S = 18 mg dm⁻³; Na = 1.4 mmol_c dm⁻³; (H+Al) = 23 mmol_c dm⁻³; CTC = 79.9 mmol_c dm⁻³ and V = 71 %; B = 0.83 mg dm⁻³; Fe = 29 mg dm⁻³; Zn = 1.7 mg dm⁻³; Cu = 1 mg dm⁻³; Mn = 10.6 mg dm⁻³.

For seedlings production, polyethylene bags (1694 cm³) were used as containers, as indicated Vallone et al. (2010). The coffee cultivar used in the experiment was the Catuaí Vermelho IAC 144, from which two seeds per bag were used, which upon reaching the stage "orelha-de-onça" were thinned, keeping one plant per container.

The seedlings were grown in nursery, covered with a polypropylene screen with 50% shade (TATAGIBA; PEZZOPANE; REIS, 2010), and irrigated with micro-sprinklers flow of 75 L h⁻¹. The control of major pests and diseases was done according to recommendations proposed by Matiello et al. (2010).

The experiment was installed in a completely randomized design with four replicates and 12 treatments in a 6 x 2 factorial scheme, with six levels of phosphorus (P): 0, 109, 218, 436, 872 and 1308 mg dm⁻³, as triple superphosphate (41% P₂O₅); and two levels of nitrogen (N): absence and 100 mg dm⁻³ in the form of urea (44% N). Each plot was composed of eight seedlings, with the six central being considered as useful for evaluations.

All assessments were performed at 180 days after sowing, when the seedlings age is considered suitable for planting (MATIELLO et al., 2010).

The following biometric characteristics were studied: 1) shoot height from apical to stem measured with a millimeter ruler; 2) root length also measured with a millimeter ruler; 3) stem diameter, measured using a caliper with an accuracy of 0.01 mm; 4) number of leaves; 5) root dry matter; 6) shoot dry matter and; 7) dry matter of the whole plant. To determine root and shoot dry matter, material was taken to the kiln with forced circulation temperature from 60 to 70 °C until obtaining a constant weight.

Based on the results of biometric analysis, Dickson Quality Index (DQI) was obtained by calculating $DQI = [TDM / (SH / SD) + SDM / RDM]$ (DICKSON et al., 1960), where TDM: total dry matter; SH: shoot height, SD: stem diameter, SDM: shoot dry matter; RDM: root dry matter.

A chemical analysis of the plant material was performed determining the content of nitrogen and phosphorus in the dry matter of the shoot. Based on the results of the levels of these nutrients and dry matter of shoots per bag, the accumulation of nitrogen and phosphorus by plants was calculated.

The analytical determinations were performed according to the methodology described by Malavolta, Vitti and Oliveira (1997).

After collecting plants for their assessments, there was the determination of phosphorus in the soil of the bags, following the methodology described by Rajj et al. (2001).

Data were subjected to analysis of variance by F test ($P < 0.05$) and regression analysis for significant effects using the statistical program SISVAR® (FERREIRA, 2011).

The coefficients of the parameters of each model were tested, picking up significant models, with higher coefficient of determination.

3 RESULTS AND DISCUSSION

The application of phosphorus resulted in increased linear fit with the content of the element in the soil, both in the absence and in the presence of nitrogen (Figure 1a), resulting in a higher accumulation of nutrient in plant also linearly (Figure 1b).

It is noted that in the presence of nitrogen there was synergistic effect for the accumulation of phosphorus in the plant, with higher accumulation of phosphorus in plant tissue in relation to the application of doses of the nutrient in the absence of nitrogen.

For nitrogen accumulation, there was also positive interaction between nutrients, because with increasing doses of phosphorus in the presence of nitrogen, there was a linear increase in the accumulation of the nutrient, which was not observed in the absence of nitrogen application (Figure 1c).

It adds up the slope of the phosphorus doses used in the preparation of the substrate providing increased nutrient accumulation by 87 % for each mg of P applied, when associated with the application of 100 mg dm⁻³ of nitrogen in relation to absence of N addition (Figure 1b), for the presence of N increases the absorption of P by the plant (PRADO, 2008). The interaction of P and N in plant tissue has been widely studied by many authors (FIALHO et al., 2012; GONTIJO et al., 2007; RONCHI et al., 2003).

The presence of the nitrogen increases the amount of lateral roots increased absorptive capacity of phosphorus (SILVA; DELATORRE, 2009). The effect could be increased with the use of a urease inhibitor in nitrogen fertilizer (GARCIA et al., 2011).

Appropriate doses and the balance between N and P to interfere in the metabolic processes of plants promote greater expansion of the cells (POOTER, 1990), stimulates protein production, fast cell division and differentiation, resulting in increased vegetative growth (HOQUE et al., 2004).

The application of phosphorus resulted in a linear increase in plant height (Table 1) and dry matter accumulation in the whole plant (Table 1), both in the absence and in the presence of nitrogen. For stem diameter, the doses of phosphorus promoted linear and quadratic increases in the absence and presence of the element, respectively (Figure 2b).

However, in the presence of nitrogen the response of seedling height, stem diameter and dry matter of the whole plant was higher in relation to the application of phosphorus doses in the absence of nitrogen. It is observed for most of the analyzed variables that the use of 100 mg dm⁻³ to prepare the N substrate for coffee seedlings potentiated the effect of phosphorus doses due to improved plant nutrition (Figure 1 b, c).

The effect of using phosphorus fertilization of coffee seedlings in increasing plant height is widely reported in the literature (GONÇALVES et al., 2009; POZZA et al., 2007). The combination of P and N enhanced the seedling height in 41 % compared to treatment only fertilized with phosphorus (Figure 2a). The importance of phosphorus in increasing the stem diameter of coffee plants was also confirmed by Marana et al. (2008) and Melo, Mendes and Guimarães (2003) using different substrates.

It appears that there was an increase with linear adjust on Dickson Quality Index according to the doses of phosphorus in the presence of nitrogen application, however there was no effect of this index in the absence of N fertilization (Figure 2d).

Note that the use of phosphorus associated with the application of N to increase this index induced improvement in seedlings, especially on quality as reported (FOCHO et al., 2011).

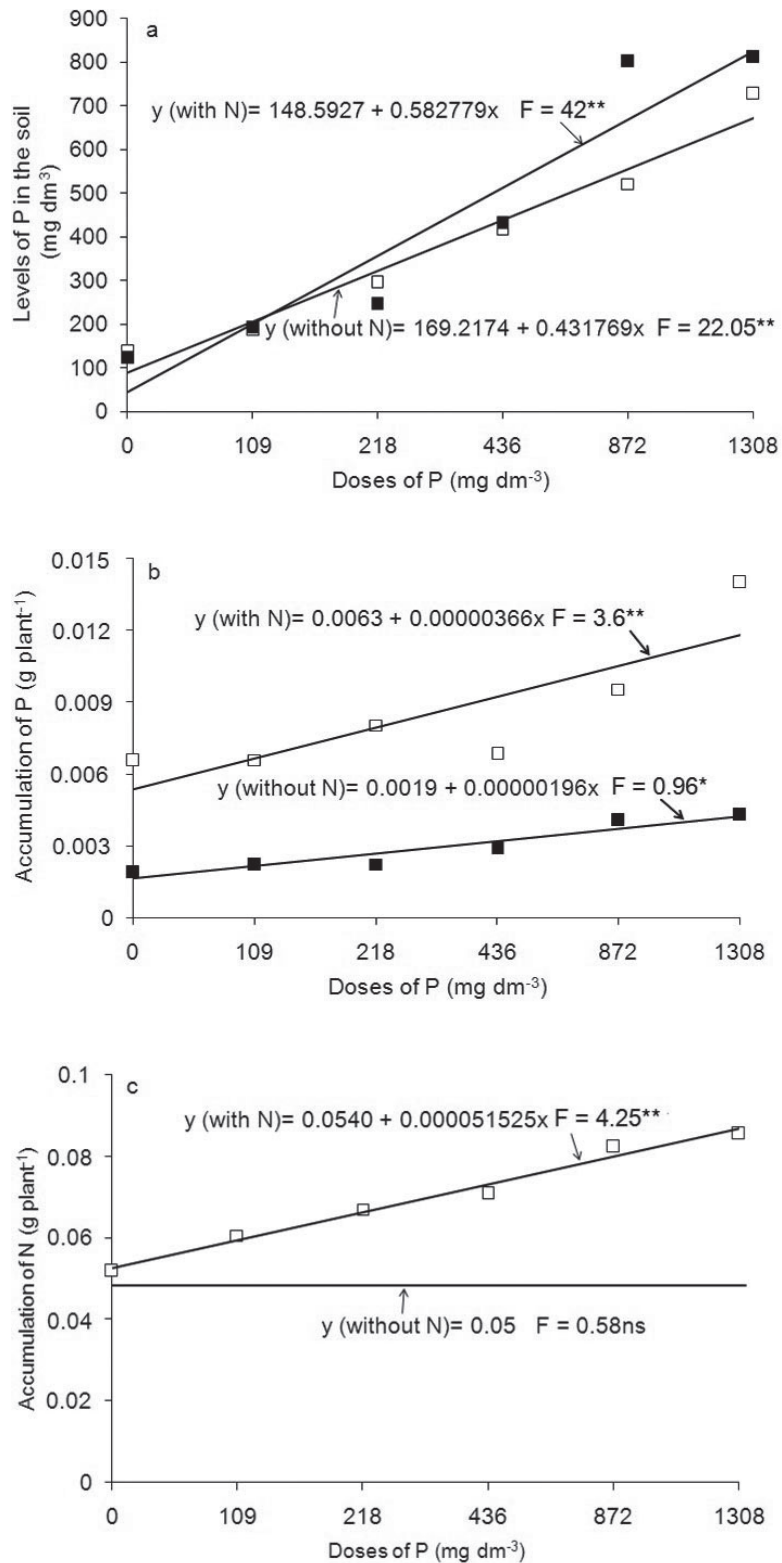


FIGURE 1 - Levels of phosphorus in soil (a), accumulation of phosphorus (b) and accumulation of nitrogen (c) of coffee seedlings, in response to doses phosphorus, with and without nitrogen. F = value of test F and $F_{(a,b)}$ = deviation value regression. ^{ns}, * e **: No significant, significant at 5% probability and significant at 1% probability by the test F, respectively.

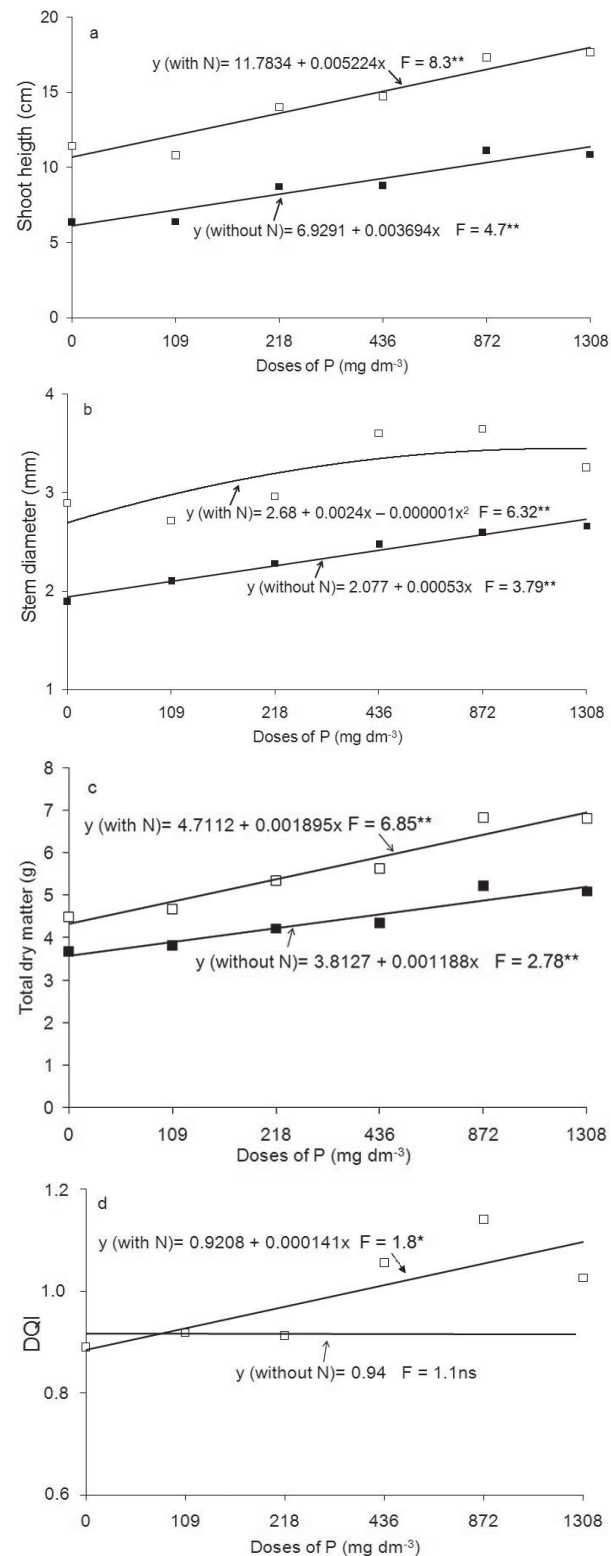


FIGURE 2 - Shoot height (a), stem diameter (b), total dry matter (c) and Dickson Quality Index (DQI) (d) of coffee seedlings, in response to doses of phosphorus, with and without nitrogen. F = value of test F and $F_{(a,b)}$ = deviation value regression. ns, * e **: No significant, significant at 5% probability and significant at 1% probability by the test F, respectively.

According to Caione, Lange and Schoninger (2012) working with seedlings of *Trema micrantha* (L.) Blume and *Schizolobium amazonicum*, Ducke respectively, found that the seedlings with higher Dickson Quality Index showed desirable variables for obtaining high-quality seedlings, which were expressed at higher values of stem diameter, dry matter of shoot, of root and of the whole plant, and lower values of the shoot / root ratio as well as of the shoot height / stem diameter.

The application of phosphorus resulted in increased linear increase in root and shoot dry matter, both in the absence and in the presence of nitrogen (Table 1).

Pozza et al. (2007) and Silva et al. (2010), who used lower doses of P in the production of coffee seedlings, obtained lower values for dry

matter of shoot and root in relation to the values obtained in this work. The effect of phosphorus on increasing production of dry matter of coffee seedlings was also observed by Gonçalves et al. (2009) testing high doses of P. Related to the dry matter of the whole plant, it can be seen by the slope an increase of 59 % for each mg of added P in the presence of N relative to its absence (Figure 2 c).

Phosphorus application without N increased with quadratic adjustment the number of leaves reaching a maximum value at a dose of 856.6 mg dm⁻³ of P, however with the association of N increase was linear. The increase in the number of leaves with the phosphorus doses were also observed by Pozza et al. (2007), demonstrating the importance of the nutrient supply in the substrate.

TABLE 1 - Shoot height (SH), stem diameter (SD), total dry matter (TDM), dry matter of roots (RDM), dry matter of shoot (SDM), number of leaves (LN), relationship between shoot height with stem diameter (SH/SD), shoot height with shoot dry matter ratio (SH/SDM), dry matter of the shoot with dry matter of roots (SDM/RDM) and dry matter of roots with dry matter of the shoot (RDM/SDM) of coffee seedlings, in response to doses phosphorus, with and without nitrogen.

N	Variable	Equation	F	R ²	F _(4,33)
Absence	Shoot height	6.9291 + 0.003694x	19.08**	0.81	0.541 ^{ns}
Presence	Shoot height	11.7834 + 0.005224x	38.16**	0.85	0.984 ^{ns}
Absence	Stem diameter	2.077 + 0.00053x	15.32**	0.81	0.197 ^{ns}
Presence	Stem diameter	2.68 + 0.0024x - 0.000001x ²	13.86**	0.81	*2.035 ^{ns}
Absence	Total dry matter	3.8127 + 0.001188x	12.5**	0.85	0.192 ^{ns}
Presence	Total dry matter	4.7112 + 0.001895x	30.17**	0.89	0.286 ^{ns}
Absence	Dry matter of roots	1.9057 + 0.000659x	12.4**	0.85	0.247 ^{ns}
Presence	Dry matter of roots	2.1791 + 0.00081x	18.74**	0.93	0.178 ^{ns}
Absence	Dry matter of shoot	1.9113 + 0.000524x	7.79**	0.81	0.319 ^{ns}
Presence	Dry matter of shoot	2.5317 + 0.001086x	33.5**	0.86	0.412 ^{ns}
Absence	Number of leaves	7.678 + 0.0137x - 0.000008x ²	12.65**	0.85	*1.794 ^{ns}
Presence	Number of leaves	12.8005 + 0.002665x	11.8**	0.73	0.417 ^{ns}
Absence	SH/SD	3.3530 + 0.000728x	9.18**	0.64	1.279 ^{ns}
Presence	SH/SD	4.0010 + 0.001018x	17.9**	0.75	1.718 ^{ns}
Absence	SH/SDM	3.6208 + 0.000751x	15.46**	0.75	0.373 ^{ns}
Presence	SH/SDM	-	0.2 ^{ns}	-	0.8 ^{ns}
Absence	SDM/RDM	-	0.1 ^{ns}	-	1.148 ^{ns}
Presence	SDM/RDM	-	0.69 ^{ns}	-	0.377 ^{ns}
Absence	RDM/SDM	-	0.68 ^{ns}	-	1.452 ^{ns}
Presence	RDM/SDM	-	0.45 ^{ns}	-	0.148 ^{ns}

** and ns = statistically significant (P<0,05) and statistically insignificant, respectively.

* = F_(3,33)

It is noted that the application of phosphorus resulted in a linear increase of the ratio SH/SD, both in the absence and in the presence of nitrogen, however in the presence of N this relationship showed higher rates. This result indicates the nitrogen promoted greater seedling growth in height than in diameter, like the fact observed by Marana et al. (2008). The application of phosphorus resulted in a linear increase in the ratio SH/SDM in the absence of N and, in the presence of nitrogen there was no significant effect. For the indexes SDM/RDM and RDM/SDM there was also no significant difference between treatments (Table 1).

4 CONCLUSIONS

The application of phosphorus in the organic compound with the addition of N enhance P concentration in soil and plant, as well as showing in the growth and production of dry matter of coffee seedlings and especially in the presence of nitrogen. The higher dose of phosphorus is the most suitable for the production of coffee seedlings. The addition of nitrogen to the substrate containing cattle manure is important to supply the need of this nutrient in the seedlings.

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