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Influence of the use of slow-release phosphate fertilizers on the growth and production of chili peppers

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Abstract
In general, fertilization recommendations for pepper are old and scarce. Because pepper is a semi-perennial crop with high yield potential and dependence on phosphorus (P), an extremely important element, as it participates in several metabolic processes, it is necessary to look for efficient alternatives for phosphate fertilization, due to its low availability and high adsorption capacity in most Brazilian soils. Slow-release fertilizers have been shown to be an excellent alternative to conventional mineral fertilization. Therefore, the objective of this study was to evaluate the effect of different sources of P on growth and yield of hot pepper (*Capsicum frutescens* L.). An experiment was carried out in a greenhouse in the JK campus of UFVJM, Diamantina - MG, Brazil, arranged in a completely randomized design with eleven treataments (absence of fertilization, mineral treatment, organic treatment and four slow-release phosphate sources: pelleted organomineral, granulated organomineral, MAP coated and triple formulated, at doses of 150 and 300 kg ha^{-1} of P_2O_5). Growth variables, fresh and dry matter accumulation and yield were evaluated 180 days after planting. The pelleted and granulated organomineral treatments at the dose of 300 kg ha^{-1} of P_2O_5, promoted the best results for the parameters dry mass of root, number of fruits per plant, fresh and dry mass of fruits and total yield. Such results can be explained by the better efficiency of P release and the better absorption of this nutrient by the plant, making it an excellent option in relation to conventional sources commonly adopted.
Keywords: *Capsicum frutescens*; nutrient use efficiency; optimization of fertilization; organomineral fertilization; slow-release fertilizers.

Influência do uso de fertilizantes fosfatados de liberação lenta no crescimento e produção de pimenta malagueta

Resumo
De modo geral, as recomendações para adubação da cultura da pimenta são antigas e escassas. E por se tratar de uma cultura semi-perene com alta produção e dependência de fósforo (P), elemento de suma importância, por participar de diversos processos metabólicos, torna-se necessário buscar alternativas eficientes para a adubação fosfatada, devido a sua baixa disponibilidade e alta capacidade de adsorção na maioria dos solos brasileiros. Os fertilizantes de liberação lenta têm se mostrado como uma excelente alternativa em relação a adubação convencional mineral. Desta forma, objetivou-se avaliar o efeito de diferentes fontes de P no crescimento e produção da pimenta malagueta (*Capsicum frutescens* L.). Realizou-se um experimento em casa de vegetação no Campus JK da UFVJM, Diamantina - MG, no delineamento inteiramente casualizado com onze tratamentos (ausência de adubação, tratamento mineral, tratamento orgânico e quatro fontes fosfatadas de liberação lenta: organomineral peletizado, organomineral granulado, MAP revestido e formulado triplo, nas doses de 150 e 300 kg ha^{-1} de P_2O_5). Foram avaliadas variáveis de crescimento, acúmulo de matéria fresca e matéria seca e produtividade aos 180 dias após o transplantio. Os tratamentos organomineral peletizado e granulado 300 kg ha^{-1} de P_2O_5 promoveram os melhores resultados para os parâmetros massa seca do sistema radicular, número total de frutos, massa fresca e massa seca de frutos e produtividade total. Tais resultados podem ser explicados

pela melhor eficiência da liberação do P pelos fertilizantes e melhor absorção do nutriente pela planta, tornando-se uma excelente opção em relação as fontes convencionais comumente adotadas.

Palavras-chave: Adubação organomineral; *Capsicum frutescens*; eficiência do uso de nutrientes; fertilizantes de liberação lenta; otimização da adubação.

Introduction

Pepper cultivation is important for Brazilian agribusiness, with positive profitability characteristics, especially when adding value to the product, and also for its social role in agriculture, since it is cultivated mainly by small farmers, demanding a large amount of labor during its cycle, especially during harvest (ALVES *et al.*, 2016; PELVINE, 2019).

In the last few years the pepper market has become more demanding, which encouraged pepper cultivation in many regions throughout Brazil, and hence led to several improvements on the sector either by releasing improved pepper varieties or by developing new recommendation practices for pepper cultivation.

Since vegetables are very demanding in nutrients, large amounts of fertilizers are required for vegetable cultivation in order to obtain significant increases in yield. Mineral nutrition is of great importance as adequate availability of micro and macronutrients contributes to overall crop development (BACKES *et al.*, 2018). Among macronutrients, phosphorus (P) stands out, since it plays a role in the transfer of energy in metabolic processes and in the synthesis of cellular structures (MARSCHNER, 2012), and has a direct effect on development and growth of crops (WYNGAARD *et al.*, 2016).

Most tropical and subtropical soils have low availability of phosphorus (P) which is normally corrected by the application of phosphate fertilizers (TIECHER *et al.*, 2017; ROY *et al.*, 2016).

Fertilization recommendations found in the literature for pepper cultivation are scarce and old, being commonly used the ones suggested by Pinto *et al.* (1999) and Casali and Fontes (1999). Further studies are therefore required in order to establish efficient and updated recommendations, given the wide availability of sources and technologies present in the agricultural market, mainly related to the gradual release of nutrients to plants, such as organominerals and coated fertilizers (BIEDERMAN; HARPOLE, 2013; MCCORMACK *et al.*, 2013; FARREL *et al.*, 2013; SOUSA *et al.*, 2020).

Organomineral fertilizers are nutrient sources that have, in their composition, a mineral part and an organic part. The protective layer composed of polymers surrounding the fertilizer grains increases the release efficiency of the mineral part to the plants and positively influences plant production reducing the amount of fertilizers applied.

The use of slow-release fertilizers, such as organominerals can supply the nutritional demand of plants throughout the crop cycle (RODRIGUES *et al.*, 2016; SEDIYAMA *et al.*, 2009). The use of organomineral fertilization is considered an alternative to provide high crop yields and better production quality (ANDRADE *et al.*, 2012).

The objective of the present work was to evaluate the effect of different sources of P on growth and yield of hot pepper (*Capsicum frutescens*).

Material and Methods

Description of the experimental area

The experiment was carried out from October, 2018 to March, 2019 in a greenhouse at the Vegetal farm unit of the Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM), JK Campus, in Diamantina – MG, Brazil (18°12'12"S; 43°34'16"O; 1,384 m of altitude). The local climate is classified as Cwb, according to the Köppen classification (ALVARES *et al.*, 2013), characterized by mild and humid summers (October to April) and cool and dry winters (June to August). The annual precipitation varies from 1,250 to 1,550 mm and the average annual temperature is between 18º to 19ºC, being predominantly mild throughout the year (GIANOTTI *et al.*, 2013).

Substrate

The substrate used was characterized as a dystrophic Yellow Latosol (SANTOS *et al.*, 2018), with a silty-clay texture, from the UFVJM experimental farm in Curvelo-MG. The soil had the following chemical and physical characteristics: $pH_{(H2O)}$ = 5.34; P = 3.55; K = 34.98 mg dm^{-3}; Ca^{2+} = 1.13; Mg^{2+} = 0.44 e Al^{3+} = 0.26; (H+Al) = 2.16; SB = 1.66; $CTC_{(t)}$ = 1.92 and $CTC_{(T)}$ = 3.82 $cmol_c dm^{-3}$; V = 43 %; m = 14.0 and organic matter - OM = 6.62 dag kg^{-1}; sand = 19; silt = 45 and clay = 36%.

Since the recommended base saturation for the crop is 70% (CASALI; FONTES, 1999), liming was carried out in order to raise the base saturation using the dose of 1,031 t ha^{-1} of limestone.

Mineral fertilization was carried out at the dose of 300 kg ha^{-1} of P_2O_5, recommended for the cultivation of peppers (CASALI; FONTES, 1999), in the fertilizer formulas NPK 00-18-00 (simple superphosphate), NPK 07-30-00 (pelleted organomineral), NPK 04-15-00 (granulated organomineral), NPK 10-50-00 (MAP coated) e NPK 00-18-00 (triple formulated, composed of simple superphosphate, MAP and natural phosphate).

Plant material

The hot pepper seedlings, cultivar Malagueta (ISLA Sementes LTDA, BRA) were produced in a greenhouse in expanded polystyrene trays (128 cells), containing commercial substrate Tropstrato® (Vila Verde, BRA), based on pine bark, vermiculite and peat. Three irrigations were carried out daily using micro sprinklers. The transplant was carried out when the seedlings had three to four true leaves.

Conduction of the experiment

A completely randomized design with eleven treatments and four replications was used. The treatments are described in Table 1.

Table 1. Description of the treatments to which the hot pepper was submitted.

Treatment	Description
Control (CT)	absence of fertilization
Pelleted Organomineral 07-30-00 (PO)	300 kg ha^{-1} of P_2O_5
Pelleted Organomineral 07-30-00 (PO 50%)	150 kg ha^{-1} of P_2O_5
Granulated Organomineral 04-15-00 (GO)	300 kg ha^{-1} of P_2O_5
Granulated Organomineral 04-15-00 (GO 50%)	150 kg ha^{-1} of P_2O_5
MAP Coated 10-50-00 (MAP C)	300 kg ha^{-1} of P_2O_5
MAP Coated 10-50-00 (MAP C 50%)	150 kg ha^{-1} of P_2O_5
Triple Formulated 00-18-00 (TF)	300 kg ha^{-1} of P_2O_5
Triple Formulated 00-18-00 (TF 50%)	150 kg ha^{-1} of P_2O_5
Mineral treatment (Simple superphosphate) (MT)	300 kg ha^{-1} of P_2O_5
Organic treatment (Filter cake) (OT)	100% of the recommended organic dose

Each experimental plot consisted of a polyethylene pot with a capacity of 9 dm³ of soil. In the MT treatment we applied 7.5 g pot^{-1} of NPK, in PO 4.5 g pot^{-1} of NPK, in PO 50% 2.25 g pot^{-1} of NPK, in GO 9.0 g pot^{-1} of NPK, in GO 50% 4.5 g pot^{-1} of NPK, in MAP C 2.7 g pot^{-1} of NPK, in MAP C 50% 1.35 g pot^{-1} of NPK, in TF 7.5 g pot^{-1} of NPK and in TF 50% 3.75 g pot^{-1} of NPK, in OT we applied 90 g pot^{-1} of filter cake.

Plants were irrigated daily to keep soil moisture close to the field capacity. Pests, diseases and weeds were also monitored daily and control measures were adopted when needed.

Characteristics Measurements

Evaluation started 130 days after transplanting, when the first harvest was carried out, with other harvests being carried out for another 50 days. We evaluated plant height (PH), fresh mass of roots (FMR), shoots (FMS) and fruits (FMF), dry mass of roots (DMR), shoots (DMS) and fruits (DMF), number of fruits per plant (NFP), diameter (DF) and length (LF) of fruits, total yield (TY) and DMS/DMR ratio.

To measure PH, a measuring tape with 100 cm in length was used.

For FMR and FMS, the stem was sectioned in base. Then, the root was washed in order to remove the soil adhered to the roots, and then weighed. Root samples were dried in a forced air circulation oven at 65 °C for 72 hours, and weighed again to determine DMR and DMS, expressed in g $plant^{-1}$.

To determine FMF, we weighed all fruits from each harvest. Fruits were then dried in a forced air circulation oven at 65 °C for 72 hours and weighed again to determine DMF. DMF values were expressed in g plant^{-1}.

NFP was determined by counting the fruits harvested during the evaluation period.

For DF and LF, a random sample of ten fruits per harvest was used. For more precise measurements we used a digital pachymeter.

Total yield was estimated based on the stand of 12,500 plants ha^{-1} (REIFSCHNEIDER, 2000).

The DMS/DMR ratio was calculated by dividing DMS by DMR.

Statistical analysis

All data were subjected to analysis of variance and the means compared by the Scott Knott test at 5% probability. Statistical analysis were performed using the computer program SISVAR (FERREIRA, 2014).

Results and Discussion

No statistical differences were found between the phosphate treatments for the variables DF and LF.

Plant height was influenced by phosphate fertilization, showing a difference in relation to the treatment without fertilization (control). However, there was no difference between treatments with fertilization. Among the phosphate sources, PO provided the best result (66.25 cm), while the CT displayed the lowest PH (41.50 cm), 37.36% lower than that obtained with the use of PO (Table 2). For all treatments, except the control, the results obtained were statistically identical, both for full and half doses, demonstrating the efficiency of the slow-release fertilizers.

The highest FMS value (155.80 g plant^{-1}) was observed for PO treatment and the lowest (107.58 g plant^{-1}) for CT. FMS did not differ for MT, OT, MAP C 50%, MAP C, TF 50% and TF treatments. The use of 50% of the dose, having pelleted and granulated organominerals as sources, showed a considerable reduction in FMS, both in comparison with the other sources and with their respective full doses (16.66% and 15.37% lower, respectively).

For DMS values, the use of PO stood out from the others, showing the highest values (50.56 g plant^{-1}), 30.06% higher than the CT, which showed the lowest (35.36 g plant^{-1}), demonstrating the ability of PO to promote increase in DMS.

It is reasonable to infer that the use of slow-release sources, with half doses, showed the same efficiency as the MT treatment.

Table 2. Plant Height - PH (cm); Fresh Mass of Shoots - FMS (g plant^{-1}) and Dry Mass of Shoots - DMS (g plant^{-1}) at 180 DAT of hot pepper plants.

Treatment	PH (cm)	FMS (g plant^{-1})	DMS (g plant^{-1})
CT	41.50 b	107.58 e	35.36 c
MT	59.50 a	136.48 c	41.46 b
OT	55.75 a	131.78 c	40.45 b
PO 50%	58.00 a	126.73 d	38.52 c
PO	66.25 a	155.80 a	50.56 a
GO 50%	58.50 a	124.00 d	39.75 b
GO	62.25 a	146.53 b	44.37 b
MAP C 50%	60.00 a	134.75 c	41.14 b
MAP C	61.00 a	135.95 c	42.29 b
TF 50%	58.50 a	134.73 c	39.86 b
TF	59.75 a	133.13 c	40.68 b
Average	58.27	133.40	41.31
CV (%)	6.35	4.34	5.48

CT: absence of fertilization; MT: Mineral treatment (Simple superphosphate); OT: Organic treatment (Filter cake); PO: Pelleted Organomineral (07-30-00); GO: Granulated Organomineral (04-15-00); MAP C: MAP Coated (10-50-00); TF: Triple Formulated (00-18-00). CV: Coefficient of variation; Different letters indicate significant differences between average within columns at the 5% probability level according to Scott Knott test.

Under favorable conditions, plants prioritize vegetative development since it is the acquired vegetative mass that supplies the need for photoassimilates that fruits demand when they start to appear. Therefore, a well-nourished plant can produce greater amounts of photoassimilates which later results into growth in height (BATISTA *et al.*, 2015; ALMEIDA *et al.*, 2019). The results found in this work supports this idea, in which, regardless of the source used, greater values of PH were observed when P was applied. However, it can be highlighted the phosphate sources, slow-release, in half of the recommended dose of P_2O_5, which presented results similar to the MT, which in turn was applied aiming to supply 100% of the recommendation for the culture.

Sediyama *et al.* (2014) obtained similar results using biofertilizer in two pepper cultivars, where they verified the increase in plant height with the increase in the dose of biofertilizer, noting the benefits of using organic sources in fertilization, which could be observed through the results obtained, with the use of PO and GO fertilizers, in this work.

Such results obtained by the PO and GO treatments (66.25 cm and 62.25 cm, respectively) can be justified by the greater availability of nutrients for plants, coming from the organic and mineral parts present in their composition, which are made available slowly and gradually, without loss by the soil or other factors, showing greater use by plants.

Phosphorus (P) acts in several metabolic processes in plants, since it is a part of the ATP (adenosine triphosphate) molecule and participates in the formation of cell membrane as a part of phospholipid composition (MARSCHNER, 2012). This reflects primarily in an adequate formation of the root system and, therefore, in the absorption of water and nutrients, which consequently promotes greater accumulation of FMS and DMS, since it is found constantly and with less loss of P, exemplified by the use of PO, showed a greater accumulation of phytomass in the shoots, which demonstrates the potential of organominerals, providing results similar or even superior to other fertilizers, since the prolonged availability of the element, allows an adjustment to the needs of the different stages phenological characteristics of the plant (QUINTANA-BLANCO *et al.*, 2017).

Similar results were obtained by Fernandes *et al.* (2020) and Sousa *et al.* (2014) with the use of organomineral and biofertilizer, respectively, in lettuce, as well as Aguiar *et al.* (2021) for sugar beets.

Regarding FMR, the managements presented similar results, with emphasis on the PO management followed by the GO, which differed from the others and displayed the highest average values, 277.10 and 242.95 g $plant^{-1}$, respectively (Table 3). It is important to highlight the increase of 45.04% in FMR promoted by the PO management in relation to CT.

For DMR, CT and OT treatments displayed the lowest average values (32.03 and 37.30 g $plant^{-1}$, respectively). As best treatments, PO, GO and MT stood out. The other treatments did not differ by the Scott Knott test at 0.05 significance level.

The treatments CT and OT displayed the highest values of DMS/DMR ratio (1.12 and 1.09), suggesting greater efficiency of the root system of plants submitted to these treatments, since there was a greater development of shoots in relation to roots. No statistical differences were found between the other treatments.

Table 3. Fresh Mass of Root – FMR (g plant^{-1}), Dry Mass of Root – DMR (g plant^{-1}) and DMS/DMR ratio at 180 DAT of hot pepper plants.

Treatment	FMR (g plant^{-1})	DMR (g plant^{-1})	DMS/DMR
CT	191.04 c	32.03 c	1.12 a
MT	226.37 c	46.40 a	0.90 b
OT	206.02.c	37.30 c	1.09 a
PO 50%	218.33 c	40.96 b	0.94 b
PO	277.10 a	53.55 a	0.95 b
GO 50%	209.82 c	40.83 b	0.98 b
GO	242.95 b	51.71 a	0.87 b
MAP C 50%	220.05 c	41.81 b	0.99 b
MAP C	223.72 c	44.86 b	0.95 b
TF 50%	209.31 c	43.61 b	0.93 b
TF	214.25 c	43.47 b	0.94 b
Average	221.72	43.32	0.97
CV (%)	6.55	10.91	11.27

CT: absence of fertilization; MT: Mineral treatment (Simple superphosphate); OT: Organic treatment (Filter cake); PO: Pelleted Organomineral (07-30-00); GO: Granulated Organomineral (04-15-00); MAP C: MAP Coated (10-50-00); TF: Triple Formulated (00-18-00). CV: Coefficient of variation; Different letters indicate significant differences between average within columns at the 5% probability level according to Scott Knott test.

According to Taiz and Zeiger (2013), the initial slow growth rates results from the fact that plants use a large part of their energy for fixation in the soil, since in this phase the roots are the preferential drain of photoassimilates.

The greater accumulations provided by the PO and GO treatments, both of FMR and DMR, can be associated with the improvements provided by the organic part present in its composition, which improves the physical and chemical characteristics of the soil and provides greater availability of nutrients for the plants (AGUILAR *et al.*, 2019; SOUZA *et al.*, 2020).

Sousa *et al.* (2014) and Oliveira *et al.* (2014) obtained similar results with lettuce under fertilization with biofertilizer and organomineral fertilizers, respectively, as well as Freitas *et al.* (2019) for lettuce seedling production, where both obtained an increase in FMR and DMR with the use of organomineral fertilizers.

However, although they did not show statistical difference for FMR, which is directly associated with the water content present at the time of the evaluation, the other treatments promoted a considerable increase in DMR. Such results can be justified by the fact of having a supply of phosphorus to the plant, providing a greater production of photoassimilates, so that it is not necessary to allocate resources only in root development, but in the general development of the plant, because when nitrogen, phosphorus and water are limited in the soil, the plant starts to allocate a greater proportion in the development of the root system (NIU *et al.*, 2013), seeking to cover a greater area of absorption of water and nutrients in the soil.

When submitted to soils with P defficiency, plants tend to have a reduction in its DMS/DMR ratio, which can be explained by the high partition of photoassimilates for the root system in phosphorus deficient plants (MARSCHNER, 2012), promoting the increase in dry root biomass (LARIGAURDERIE; RICHARDS, 1994), on the other hand, the development of shoots is limited.

Marschner (2012) states that the relationship between shoots and root system drops from 5.0 to 1.9 in bean plants submitted to P deficiency. Cruz *et al.* (2015) observed a reduction in the root:shoots ratio of *Physalis angulata* plants, when compared to plants under deficiency and with good availability of P, as well as Sá *et al.* (2014) also found promising effects on the root:shoots ratio in yellow passion fruit with the use of goat manure. However, the results obtained in the present work contradict those obtained by the authors above, since the treatments with the highest DMS/DMR ratio were precisely the CT and MT, which have no and low supplementary supply, respectively.

Hot pepper showed a positive response to the number of fruits per plant, in the managements, which can be seen in the CT, which presented the lowest number of fruits (189.75) (Table 4). Among the managements, we can highlight PO, GO and TF, which presented the highest average NFP values, with 300.75, 285 and 271.75 respectively. Thus, we can infer the efficiency in the use of these sources, since phosphorus is a nutrient of great importance for fruit setting and fixation on the plant.

For average values of fresh mass of fruits, the PO and GO treatments presented the highest average values, differing from the others, being followed by TF and MAP C. It is also possible to highlight the similarity of the managements with half of the recommended dose of P_2O_5 and the MT and OT managements, which clearly shows the efficiency of slow-release fertilizers, and its use can be strongly recommended.

For DMF, the PO and GO treatments promoted a greater significant accumulation of dry mass, while the CT presented the lowest average value for this parameter.

As for total yield, we can observe the satisfactory effect of the PO and GO managements, which showed an increase of 111.4% and 94.42%, respectively, in relation to the CT, in addition to 40.45% and 29.17% compared to MT. This increase confirms the efficiency of PO and GO fertilizers for hot pepper cultivation.

Table 4. Number of Fruits per Plant – NFP; Fresh Mass of Fruits – FMF (g $plant^{-1}$); Dry Mass os Fruits – DMF (g $plant^{-1}$) and Total Yield – TY (Kg ha^{-1}) at 180 DAP of hot pepper.

Treatment	NFP	FMF (g $plant^{-1}$)	DMF (g $plant^{-1}$)	TP (Kg ha^{-1})
CT	189.75 d	53.94 d	16.31 d	674.24 d
MT	251.75 b	81.19 c	23.36 c	1014.81 c
OT	243.25 b	74.87 c	22.12 c	935.81 c
PO 50%	218.50 c	70.18 c	20.62 c	877.29 c
PO	300.75 a	114.03 a	31.40 a	1425.38 a
GO 50%	224.25 c	72.62 c	21.06 c	907.75 c
GO	285.00 a	104.87 a	29.14 a	1310.90 a
MAP C 50%	251.25 b	80.82 c	25.27 b	1010.22 c
MAP C	257.50 b	93.20 b	25.85 b	1164.94 b
TF 50%	259.00 b	74.28 c	22.35 c	928.54 c
TF	271.75 a	90.35 b	24.73 b	1129.41 b
Average	250.25	82.76	23.84	1034.48
CV (%)	7.16	14.30	8.57	14.30

CT: absence of fertilization; MT: Mineral treatment (Simple superphosphate); OT: Organic treatment (Filter cake); PO: Pelleted Organomineral (07-30-00); GO: Granulated Organomineral (04-15-00); MAP C: MAP Coated (10-50-00); TF: Triple Formulated (00-18-00). CV: Coefficient of variation; Different letters indicate significant differences between average within columns at the 5% probability level according to Scott Knott test.

The results obtained, regarding NFP, corroborate to those obtained by Sediyama *et al.* (2009) for peppers plants, where the number of fruits per plant increased to the highest applied dose of organic compost associated with the highest dose of mineral fertilization, and by Silva *et al.* (2019), who obtained a linear increase for NFP associated with an increase in the dose of bovine manure.

Santos *et al.* (2019) working with sesame, BRS Seda and Preto, claim that the number of fruits per plant of both cultivars was favored by organomineral fertilization.

A study performed by Oliveira *et al.* (2004) indicates that NPK nutrients play an important role in increasing fruit production per plant since pepper plants demand high amounts of N and K. Rabelo (2015) obtained similar results with processing tomato plants.

This increase in NFP, can be explained by the fact that, the slow-release of nutrients, provides an increase in plant nutrition and growth, as the combination of organic and mineral sources makes better use of nutrients through the timing of release along its development (ANTILLE *et al.*, 2014; MALAQUIAS; SANTOS, 2017), as opposed to the severe abortion of flowers when the pepper is deficient in P (SILVA, 2013), explains the low productivity and number of fruits per plant in the CT, which relied only on the P present in the soil used.

In parallel, slow-release fertilizers suppressed the great need for phosphorus, which is only behind N and K, as one of the nutrients most absorbed by fruits (CHARLO *et al.*, 2012; OLIVEIRA *et al.*, 2015), thus promoting a greater accumulation of FMF. Similar results were obtained by Sediyama *et al.* (2012) with cucumber and by Coimbra *et al.* (2013) with processing tomato, which presented the highest values of FMF.

The increase in DMF is associated with reduction in DMS snd DMR since plants tend to send photoassimilates to the fruits, preferential drains, resulting in greater production of dry mass of fruits. According to Marschner (2012), when plants reach the fruit setting stage, carbohydrates and other photoassimilates are translocated from leaves to fruits. Similar results were obtained by Marcussi *et al.* (2004) and Charlo *et al.* (2011) in pepper cultivation.

The gains obtained for FMF, in PO and GO management, emphasize the importance of using organic sources in fertilization, generating a satisfactory increase in productivity of 40.45% and 29.17%, respectively, when compared to MT. According to Ribeiro *et al.* (2000) the application of organic fertilizer in the absence of mineral fertilizer, in the pepper culture, provided an additional gain of 3.5 t ha^{-1} in relation to the control, however, when associated with the mineral fertilizer, this additional gain was 7.0 t ha^{-1}.

The composition of organomineral fertilizers meets the nutritional requirements of hot peppers, probably due to the balanced supply of macro and micronutrients and their slow-release during the crop cycle, in addition to improved soil structure, improvements associated with the composition of the organic part. On the other hand, the additive effect of mineral fertilization can be attributed to the fact that it has nutrients more readily absorbable by plants, which favors growth, especially at first plant stages.

Conclusions

Slow-release phosphate sources proved to be efficient for hot pepper cultivation, presenting results superior to those obtained with conventional mineral fertilization and, when adopted half of the recommended dose of P_2O_5, were similar to conventional mineral fertilization.

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Declarations of conflict of interest

The authors report no declarations of conflict of interest.

Authors' Contributions

Authors 1 and 3 prepared the study and conducted the writing of the manuscript. Authors 1, 2, 4, 5 and 6 performed the evaluations of the parameters analyzed in the study. All authors read and approved the final manuscript.

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