PHOSPHORUS DIFFUSION OF ORGANOMINERAL FERTILIZERS IN SAMPLES OF SANDY SOIL ASSESSED IN PETRI PLATE

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Abstract
Based on the increasing trend in the consumption of granulated organic mineral fertilizers (OMF) in Brazil, it's concluded which the insertion of the product in the domestic market depends mainly on technological advances. Investment in technologies it's makes necessary to meet the market demand with products of proven quality, which will provide differentials attractive, such as: the supply of essential nutrients or micronutrients for agricultural production and adequation of mechanized application. These fertilizers have an excellent environmental and economic appeal, since they are an alternative for the use, as raw material, of agro-industrial residues that can be enriched with mineral fertilizers containing phosphorus (P), micronutrients and/or other nutrients of agricultural interest. This work aimed to evaluate the diffusion of phosphorus present in OMF by the Petri dish bench methodology, fast and non-destructive, in samples of sandy soil, collected in Seropédica, RJ. Two OMF were used, produced at Embrapa Solos from different carbon sources, containing MAP in its formulation, in relation to mineral fertilizer (MAP). The effect of doses of P on the OMF and MAP granulate and the effect of the incubation time on the diffusion of P were evaluated. The results indicated that at least 4 mg of P per fertilizer sample is required for greater efficiency of the detection methodology used. The source of raw material used in the production of the OMF did not interfere in the diffusion of P having a diffusive behavior similar to MAP.

Keywords: alternative sources of nutrients, diffusive flow, phosphate fertilization.

INTRODUCTION

The organomineral fertilizers (OMF's) is presented as a technological, environmental and commercially viable alternative for the rational disposal of agro-industrial waste and their use allows the use of nutrients contained in this waste. The Brazilian OMF's market, in 2019, grew 19.5% in relation to the previous year, totaling approximately 1.09 billion reais (ABISOLO, 2020).

The diffusion process is primarily responsible for the transport of P to the roots and is affected by factors such as: the phosphorus-colloid interaction in the soil, the content of the element, texture, volumetric water content in the soil and the distance to be covered down to the roots, beyond the temperature (Novais & Smyth, 1999; Costa et al., 2006; 2009).

The methodology developed by Degryse and McLaughlin (2014) allows to evaluate the diffusion in the soil of phosphorus present in fertilizers, in a simple and non-destructive way, using a filter paper containing iron oxide to capture the diffused P on the surface of a Petri dish filled with soil. This method has been used to evaluate the diffusion in the soil of mineral fertilizers because it is fast, economical and with low generation of residues during the process of analysis, and can be a tool for the development of studies that contain granulated OMF's with P.

This work aimed to evaluate the diffusion of phosphorus in OMF's by the Petri dish method, in samples of sandy soil, collected in Seropédica, RJ. Two OMF's were used, produced at EMBRAPA Solos from different carbon sources, containing MAP in its formulation, in relation to mineral fertilizer (MAP). The effect of doses of P on the granules of OMF's and MAP and the effect of the incubation time on the diffusion of P in the sandy soil samples contained in the Petri dishes were evaluated.

MATERIALS AND METHODS

The experiment was conducted at the Fertilizer Technology Laboratory of EMBRAPA Solos, Rio de Janeiro, in the randomized block design, in a 3 x 2 x 5 factorial scheme, with three replications, three fertilizers (two OMF's and MAP), two doses of P (2 and 4 mg plate^{-1} of P) and five incubation periods (8, 24, 48, 72 and 144 h).

The agro-industrial residues used to produce the OMF's were: chicken litter (CL), a compound produced with swine waste (CS). All OMF's were produced from the mixture of different milled and passing agro-industrial residues in the same sieve (<0.850 mm) and mixed with MAP, aluminum silicate and additives. All fertilizers were analyzed chemically according to Brazil (2017) and the results, in % P_2O_5 total, were: OMF_CL (25.0); OMF_CS (26.5) and MAP (45.4).

The soil sample was collected in Seropédica-RJ, in the 0-20 cm layer, dried in the air and subjected to manual fragmentation and sieving in 18 mesh. After sieving, the samples were characterized chemically and physically, according to Teixeira et al. (2017), and the results obtained were: pH (water): 6.0; Corg - 11.2 g kg^{-1}; P available: 18 mg kg^{-1}; Available K: 0.27 mg kg^{-1}; Ca: 2.0 cmolc kg^{-1}; Al: 0 cmolc kg^{-1}; T: 5.6 cmolc kg^{-1}; Clay: 120 g kg^{-1}; Silt: 98 g kg^{-1} and Sand: 782 g kg^{-1}.

After analyzing the P content in the OMF's, the granules were weighed individually and granules were separated with 2 and 4 mg of P.

To visualize the diffusion of phosphorus, the non-destructive method proposed by Degryse and McLaughlin (2014) was used. Selected fertilizer granules were deposited in the center of Petri dishes filled with moist soil and the deposition holes were covered with soil. Petri dishes were incubated and filters deposited to monitor the diffusion of P after 8, 24, 48, 72 and 144 hours of incubation After the incubation periods, the available P captured in the filter paper impregnated with iron oxide was developed, being revealed by the addition of the malachite green dye. The quantification of the diffusion halos was performed by counting pixels in the digitalized images using the GIMP program (version 2.8), where the phosphorus diffusion radius was calculated.

The data obtained were subjected to analysis of statistical methods, and the Variance and the Means were compared using the Tukey test at 5%, using the Sisvar software (version 5.6).

RESULTS AND DISCUSSION

The results of P diffusion due to the application of different doses and sources of fertilizers, at different incubation times, are shown in Table 1. For the 144 hours incubation time, it was not possible to visualize the halo due to the diffuse impregnation of the filter paper, making it impossible to read through the pixel counting program, for this reason the evaluation at this time was discarded from the results. This was possibly due to the radial dilution of P in the soil as it moves away from the granule, making it difficult for P to react with the solution present in the filter paper.

Table 1. Phosphorus diffusion radii in the soil as a function of the application of different doses and sources of granular fertilizers after four incubation times.

Fertilizers[1/]	Incubation times (hours)							
	8		24		48		72	
	Dose of P (mg granuler^{-1})		Dose of P (mg granuler^{-1})		Dose of P (mg gr^{-1})		Dose of P (mg grain^{-1})	
	2	4	2	4	2	4	2	4
	---mm---							
OMF_CL	9,42Ba[2/]	10,90Aa	11,26Ba	14,33Aa	12,30Ba	16,01Aa	13,36Ba	16,73Aa
OMF_CS	10,09Aa	11,10Aa	12,06Ba	14,55Aa	13,83Ba	16,41Aa	14,60Ba	17,60Aa
MAP	10,05Aa	11,09Aa	11,77Ba	13,62Aa	13,45Ba	16,02Aa	14,17Ba	17,20Aa
Mean	9,85	11,03	11,70	14,16	13,19	16,15	14,04	17,18

[1/] OMF: organomineral fertilizer; CL: chicken litter, CS: compound produced from swine waste and MAP: commercial monoammonium phosphate. [2/] For each incubation time, equal letters, uppercase on the line and lowercase on the column, do not differ statistically from each other by the Tukey Test at 5%.

There was an effect of P doses applied to the soil during the last three incubation times (24, 48 and 72 h). In general, the diffusion rays were greater for the highest doses applied. When the phosphorus dose applied to the soil is increased, the diffusion coefficient increases, due to the progressive saturation of the adsorption surface, which results in an increase in the concentration of phosphorus in the soil solution (Costa et al., 2006; Santos et al., 2005).

The discrimination between fertilizers regarding the diffusion of P was not observed in any of the two doses, since the diffusion rays did not differ statistically between the OMF's and the mineral fertilizer, that is, the phosphorus applied in the form of OMF, for all the matrices, had the same behavior in the soil as applied in the form of mineral fertilizer. Souza et al. (2015), however, observed less diffusive flow in the soil by the super triple mineral fertilizer in relation to the organomineral, a fact that the authors attribute to a possible protective effect of the organic complexes to the fertilizer.

Analyzing the results of the diffusion radius of P at different incubation times, it was observed that the diffusion halo has an increasing of kinetics up to 72 h. Andrade (2005) also found that the incubation period influenced the diffusive flow of P, with an initial increase in the diffusive flow of P, followed by its decrease. Machado et al. (2011) observed a decreasing trend in the availability of P as the nutrient remained in contact with the soil, in less significant values in sandy soils and especially in soils with a higher clay content.

CONSIDERATIONS

The addition of organic residues to the fertilizer formulations did not interfere in the diffusion radius of P, indicating the diffusion kinetics of OMF in a sample of sandy soil similar to the commercial mineral product of high solubility (MAP).

The period of up to 72 h of incubation, in a sample of sandy soil, proved to be adequate for evaluating the diffusion kinetics of P in OMF and MAP.

Higher doses of P in the OMF and MAP granules resulted in a higher diffusion rate of P in a sandy soil sample.

The Petri dish method was efficient for evaluating the diffusion of P in the soil using organomineral fertilizers.

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