Soil fertilization with the use of basalt and animal residues and their effects on soybean yield

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ABSTRACT

The use of basalt used with animal residues can be an efficient fertilizer alternative for soybean crops. The objective of this study was to evaluate the effect of doses of basalt powder with cattle manure and chicken litter on soybean yield, using soluble chemical fertilization (NPK) as a reference. The experiment was carried out in DBC with factorial arrangement (5 x 2) + 1, in four replications, using five basalt doses (0, 4, 8, 12 and 16 t ha-1) associated with cattle manure and chicken litter and an additional treatment with soluble chemical fertilization (NPK). The following parameters were evaluated: number of pods per plant, number of grains per pod, weight of one thousand grains and yield. The yield of soybean cultivated with basalt and chicken litter was on average 3,462.8 kg ha-1 and with cattle manure it was 3,439.2 kg ha-1. There was no effect of basalt rock dust and animal residues on any of the soybean yield components, but even so, expressive values were obtained, maintaining good yield results. The components of soybean production and yield found with the application of basalt associated with the residues were the same as those found with the use of soluble chemical admixture.

Keywords: Fertilization, Chicken litter, Agronomic characteristics, Remineralizing cattle manure.

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INTRODUCTION

The expansion of soybean cultivation and productivity is associated with technological advances in production, especially management and fertilization. Currently, the most common form of fertilization in agriculture is through industrialized sources of nutrients, which are basically soluble fertilizers such as NPK (a mixture of different concentrations of nitrogen, phosphorus, and potassium), in addition to other micronutrients specific to each type of soil and crop (PEIXOTO *et al*., 2018; TOSCANI; CAMPOS, 2017).

Brazil imports about 85% of the fertilisers it uses in agriculture. This reality shows a high level of external dependence and leaves the Brazilian economy vulnerable to fluctuations in the international fertilizer market (BRASIL, 2021).

Given this agricultural scenario, research has been advancing to propose alternative sources of fertilizers, with remineralizers/rock dust, which are ground rocks that have minerals capable of providing nutrients to plants, meeting their needs (ALMEIDA JÚNIOR *et al*., 2022).

Among the rocks that can be used in agriculture, basalt has a good potential due to its rich chemical composition, as it has variable amounts of nutrients that can be presented with greater or lesser ease of solubilization, thus contributing to the residual effect for a long period (FERREIRA *et al*., 2009; THEODORO *et al*., 2012).

As basalt rock dust has a low solubilization, one of the alternatives to increase its dissolution is the association with materials that have great biological activity, such as animal waste such as chicken litter and cattle manure. Because they have great biological activity, they can increase the rate of solubilization of minerals and favor the release of nutrients that are associated with the composition of the rock (SILVA *et al*., 2012), in addition to being sources of nutrients and having the potential to improve soil quality.

There are few studies that use basalt rock dust in association with chicken litter and cattle manure in the cultivation of grains and research needs to be intensified. Thus, the objective of this study was to evaluate the effect of doses of basalt rock dust associated with chicken litter and cattle manure on soybean yield, using soluble chemical fertilization (NPK) as a reference.

MATERIAL AND METHODS

The work was carried out in 2022, at the Professor Alcibíades Luiz Orlando Experimental Station located in the municipality of Entre Rios do Oeste-PR, belonging to the State University of Western Paraná - Campus Marechal Cândido Rondon-PR (UNIOESTE/MCR). The geographical coordinates are 24º40'32, 66" south latitude and 54º16'50.46" west longitude, at 244 meters altitude.

The soil of the experimental area is classified as a typical Eutroferric Red NITOSOL, with a very clayey texture, with smooth undulating relief (SANTOS et al., 2018) and presented the following results at a depth of 0.00-0.20 m: 28.5 mg dm-3 of P; 2.3 cmolc dm-3 of K; 5.9 cmolc dm-3 of Ca; 1.8 cmolc dm-3 of Mg; 14.1 g dm-3 of CO; 5.3 pH (CaCl2); 4.6 H+Al; as well as granulometry: 706.8 g $^{kg-1}$ of clay, 182.9 g $^{kg-1}$ of silt, 166.3 g $^{kg-1}$ of sand.

According to the Köppen climate classification, the climate of the region is of the subtropical humid mesothermal type (Cfa), with hot summers, average temperatures above 22ºC and winters with average temperatures and below 18ºC and an average annual rainfall of 1600-1800 millimeters (CAVIGLIONE et al., 2000).

The experiment was conducted in randomized blocks (DBC) in a factorial arrangement (5 x 2) + 1, with four replications. Five doses of basalt powder (0, 4, 8, 12 and 16 t $^{ha-1}$) were tested combined with two sources of animal residues: cattle manure and chicken litter. The treatment consisted of the use of soluble chemical fertilization in the soybean sowing furrow at a dose of 300 kg $^{ha-1}$ of the commercial formulation 02-20-18 (NPK). The plots had eight sowing rows with a total area of 40 m2 (5x8 m) and a useful area of 28 m2.

Prior to soybean sowing, basalt rock powder was manually applied at the studied rates and 5.0 t $^{ha-1}$ of animal residues on the soil surface and in the total area of each plot.

Soybean sowing was carried out mechanically in October 2020. The cultivar M 5947 IPRO was used, with a spacing of 0.50 m between rows, and approximately 15 seeds/linear meter were distributed. The cultivar has an indeterminate growth habit, with an early cycle and a maturation group of 5.9.

After sowing, constant monitoring was carried out in order to carry out the necessary cultural treatments of the crop. To control spontaneous plants, manual weeding was performed. Monitoring was carried out with a beating cloth to assess the presence of pests and perform phytosanitary control when necessary.

The evaluation of the production components (Number of pods per plant, Number of grains per pod) was carried out in ten plants of the useful area of each plot when they were at the R8 stage. The number of pods per plant was determined by quantifying all pods with grains, calculating the average number of pods per plant. The number of grains per pod was determined by counting the viable grains per pod. The average number of grains per plant was calculated by multiplying the average value of the number of grains per pod by the number of pods found per plant.

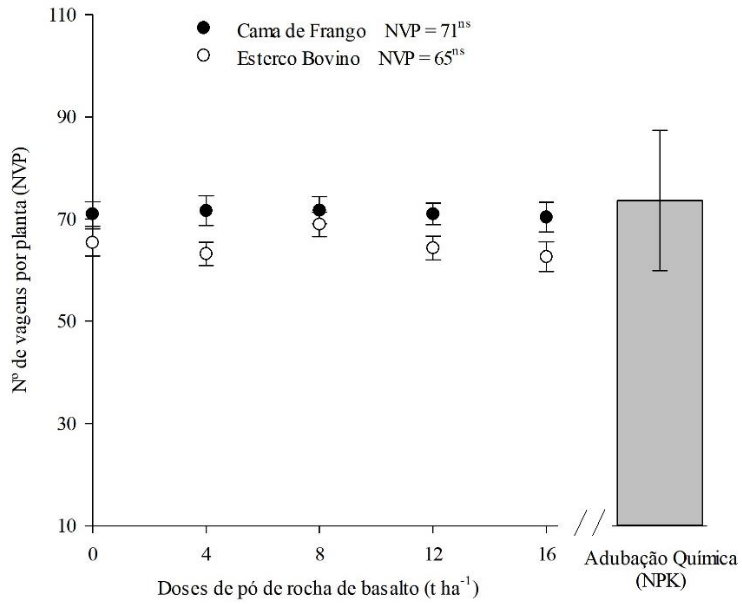
The yield (kg $^{ha-1}$) of soybean was determined when the crop was at the R8 stage (physiological maturation). The plants were collected from the useful area of the plot, being threshed and weighed on scales. The moisture content of the grains was determined and their weight was corrected to 13% moisture content and the results were expressed in kg $^{ha-1}$.

Once the assumptions were met, analysis of variance (ANOVA) was performed at the level of 5% significance for test F. For the doses within each residue, the data were submitted to polynomial regression analysis, and the model that best fit the investigated phenomenon was chosen. To compare the treatments (doses of rock dust and animal residues) with the additional control (soluble fertilization), the Dunnett test (5% probability of error) was applied, where the Dunnett DMS was calculated, which was added and subtracted from the mean value of the control to obtain a margin of comparison.

RESULTS AND DISCUSSION

The doses of basalt rock dust and animal residues did not promote significant changes in the number of pods per plant (NVP), number of grains per plant (NGP), thousand grain mass (MMG) and soybean yield, as well as the values of these variables were equal to those obtained in soluble chemical fertilization (Figures 1, 2, 3 and 4 respectively).

Figure 1 - Number of soybean pods per plant (NGV) as a function of doses of basalt rock dust and animal residues. ^{ns}: Not significant for polynomial regression fitting. Notes: Dot bars indicate the average error. Chemical Fertilization Bar indicates Dunnett's DMS (5% error).

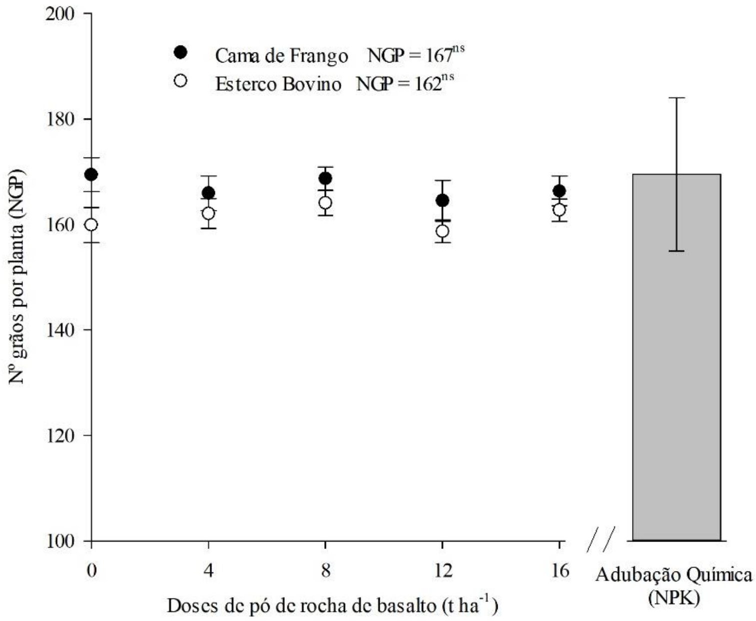


Alovisi et al. (2020), working with the application of rock dust doses ranging from 0 to 10 t $^{ha-1}$, did not find a significant effect of the doses on NVP, obtaining an average of 74 pods per plant. Different results were observed by Sustakowski (2020), in this case with the basalt rock dust dose of 6.9 t $^{ha-1}$ presented the highest NVP (85.25); that is, about 17 pods more than the amount obtained without the application of rock dust, which gave an increase of 25%.

For Bárbaro et al. (2006), the number of pods per plant is one of the most important for determining grain yield, and Carpentieri-Pípolo et al. (2005) found that plants with a higher number of pods also had higher seed weight per plant, which can interfere with the final yield.

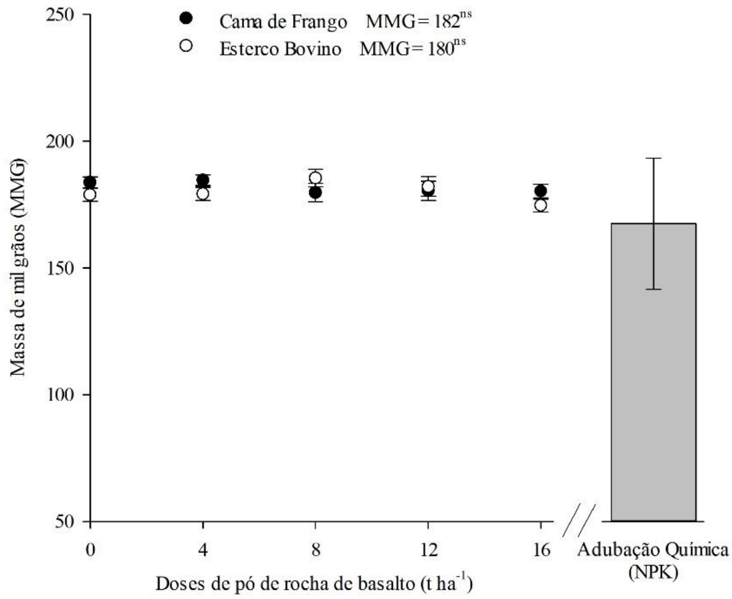
Despite the absence of effect of the treatments on the NGP, it presented considerable and close mean values (Figure 2).

Figure 2 - Number of soybean grains per plant (NGP) as a function of doses of basalt rock dust and animal residues. ^{ns}: Not significant for polynomial regression fitting. Notes: Dot bars indicate the average error. Chemical Fertilization Bar indicates Dunnett's DMS (5% error).



The mass of one thousand grains for the cultivar of SOYBEAN M 5947 IPRO is on average 170 g, and values above the average were found in this study with the use of chicken litter (182 g) and cattle manure (180 g) in the different basalt doses tested, which is a good result that even though there was no effect of the treatments on this variable, however, considerable MMG values were obtained from soybean (Figure 3).

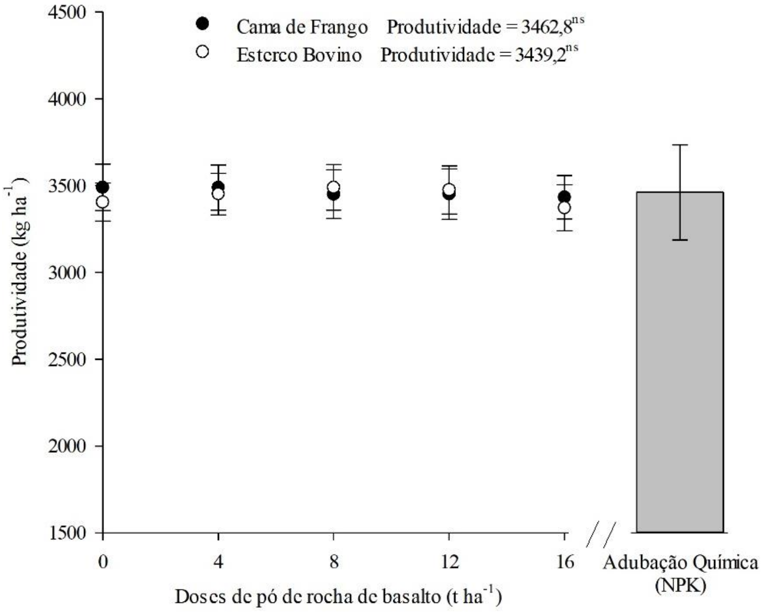
Figure 3 - Mass of one thousand grains (MMG) of soybean as a function of doses of basalt rock dust and animal residues. ns: Not significant for polynomial regression fitting. Notes: Dot bars indicate the average error. Chemical Fertilization Bar indicates Dunnett's DMS (5% error).



Almeida Junior et al. (2020) when evaluating the application of different doses of rock dust did not find a significant effect on the mass values of one thousand grains, however the values found by the authors are higher than those found in the present study. In general, the authors found an average weight of 1,000 grains of 197.5 g for the doses of 3, 6, 9 and 12 t $^{ha-1}$. On the other hand, Silva et al. (2019) also observed the effect of rock dust doses on the mass of one thousand grains, however the highest mass was at the dose of 6 t $^{ha-1}$, with a value of 155 g per thousand grains.

The yield of the crop was close to the national average of the 20/21 harvest (3,527 kg $^{ha-1}$) and that of the State of Paraná (3,535 kg $^{ha-1}$), being obtained in the cultivation of soybean subjected to basalt doses with chicken litter a productivity of 3,462.8 kg $^{ha-1}$ and with cattle manure of 3,439.2 kg $^{ha-1}$ (Figure 20).

Figure 4 - Soybean yield as a function of doses of basalt rock dust and animal residues. ns: Not significant for polynomial regression fitting. Notes: Dot bars indicate the average error. Chemical Fertilization Bar indicates Dunnett's DMS (5% error).



The productivity of the treatments used did not differ from that found with the use of soluble chemical fertilization, a very positive fact that reinforces the idea that the use of these inputs can favor the yield of the crop as much as the chemical fertilizer, and can be an alternative to complement or even substitute use over time. Silva et al. (2020), who for two consecutive seasons evaluated the effect of basalt powder doses (5, 10, 20, 40, 60, 80, 120, 160 and 200 t $^{ha-1}$) and chemical fertilization (NPK) on the black bean crop, found that doses from 5 to 60 t $^{ha-1}$ had an equivalent action on productivity compared to chemical fertilization.

Although it did not provide significant answers for the polynomial regression models tested, the average results obtained from the yield components were positive and within the reference values found for the crop, a reflection that may have been influenced by the nutrient contents in the soil and in the leaf and that contributed in an essential way to the yields obtained.

According to Lana et al. (2003), there is a direct relationship between soil fertility and soybean yield, which is directly dependent on the available concentration of nutrients in the soil solution. Therefore, basalt rock dust and animal residues were efficient in providing nutrients to maintain soybean production; thus resulting in adequate average values of grain yield.

Recent studies have shown some divergences in relation to the results obtained when using remineralizers in species of agricultural interest (AGUILERA et al., 2020). De Morais et al. (2020), when evaluating the soybean crop, after application of doses of amethyst powder, obtained an increase in the number of pods per plant, however, there was no change in grain yield, regardless of the doses applied.

For Aguilera et al. (2020), the doses of basalt rock dust (0, 1, 3 and 5 t $^{ha-1}$) did not influence the yield of three soybean cultivars, but contributed to obtain a better grain size and, thus, improve their quality.

On the other hand, Almeida Júnior et al. (2020) used doses of 0 to 24 t $^{ha-1}$ of basalt in soybean crops and obtained changes in the productive components for all agronomic characteristics tested and for yield, with an increase of 59% (dose of 24 t $^{ha-1}$ with 5,338 kg $^{ha-1}$) values above the national average (3,337 kg $^{ha-1}$, CONAB, 2023) in favor of the remineralizer.

According to Sustakowski (2020), the highest soybean yield (3,590.23 kg $^{ha-1}$) was obtained at the basalt dose of 8.4 t $^{ha-1}$; that is, an increase of 16% in relation to the productivity obtained without the application of rock dust (3,083.80 kg $^{ha-1}$).

In general, the lack of significant effects associated with the use of rocks can be linked to a number of factors such as the short cycle of the crop used as a "pilot" plant, short evaluation period, climatic conditions unfavorable to weathering and extremely sterile soils or soils with low microbial activity (SILVA et al., 2008), factors that are directly related to the remineralization capacity resulting from the use of rock dust.

In this sense, significant results can be obtained in successive crops, which is recommended when working with soil remineralizers that have a medium to long-term residual effect.

CONCLUSIONS

There was no effect of basalt rock dust and animal residues on any of the soybean yield components, but even so, expressive values were obtained, maintaining good yield results.

The components of soybean production and yield found with the application of basalt associated with the residues were the same as those found with the use of soluble chemical admixture.

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