Use of rock powder and organic fertilizer as a source of nutrients for maize crop

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Abstract. The use of rock powder as a source of nutrients to plants can be an alternative or complement to mineral soluble and organic sources, reducing the costs and the environmental pollution. Thus, the objective of this study was to present data from a long-term field trial, installed in 2015 at Federal University of Fronteira Sul, in Erechim City, in Rio Grande do Sul State, in Brazil. The data presented here evaluates the effects of applying increasing rates of rock powder (0, 3, 6, 9 and 12 t ha^{-1}), associated or not to organic fertilizer, on the soil chemical attributes and maize yield (crop season 22/23). The experiment was carried out in completely randomized blocks, with three replicates. The organic fertilizer used were bovine manure and egg-laying hen manure, while the rock powder was obtained from an extrusive igneous rock miner company (as grinding residue). The rock powder and organic fertilizer were applied on the soil, without incorporation. The soil is classified as Latossolo Vermelho Aluminoférrico típico, which corresponds to Oxisol. The rock powder associated with organic fertilizer increased potassium content in the soil. The organic fertilizer, regardless of rock powder rates, increased maize yield, soil pH and phosphorus content in the soil.

Keywords. Rocking, remineralization; alternative fertilization; organic fertilizers.

1. Introduction

From an agroecological point of view, it is essential to enhance agricultural systems, aiming for sustainable production through efficient resource utilization and minimal reliance of external inputs [1].

Maize is one of the most important crops for ensuring food security and animal feed. Brazil ranks among the top three global maize producers, making it a significant contributor to the country's foreign currency earning.

In addition to the economic aspects, maize is essential on small family farms that produce for self-consumption. However, in order to produce high yields, nutrients sources with high economic and environmental costs have to be used.

In this context, the research has been waking of use rock powder as a source of nutrients to plants [2, 3, 4]. Rock powder is a residue from the crushing process at mining companies, becoming an obstacle for the miner, due to its space-consuming, as well as a potential risk of environmental pollution. Therefore, utilizing rock powder as a nutrient source for crops could provide a way of disposing of this material. But, the main limitation of the rock powder use in agriculture is related to the gradual solubilization and release of nutrients to plants [1].

Based on that, the objective of this study was to present partial data from a long-term trial that evaluated the ability of rock powder, associated or not to organic fertilizer, to produce changes in soil chemical attributes and to improve maize crop yield in the 2022/23 crop season.

2. Research methods

The trial was installed in November 2015, at experimental area of Federal University of Fronteira Sul in Erechim City, in Rio Grande do Sul State, in Brazil. The trial is being monitored and evaluated to understand the long-term behavior of rock powder application. According to Köppen classification, the climate of the region is fundamental type C, subtype fa (Cfa), characterized as humid subtropical, without dry season, with the temperature of the hottest month exceeding 22 ºC, average annual temperature of 18.2 ºC and average annual precipitation of 1,869 mm. The soil is classified as Latossolo Vermelho Aluminoférrico típico [5], which corresponds to Oxisol, in American Soil Taxonomy System [6]

The experiment was carried out in completely randomized blocks, in a factorial arrangement 5 (A) x 2 (B), with three replicates. Rock powder doses were allocated (0, 3, 6, 9 and 12 t ha^{-1}) in factor A, and in factor B applying or not the organic fertilizer, totaling ten treatments.

The rock powder was obtained in an extrusive igneous rock miner of Serra Geral formation, located in São Domingos do Sul City, Rio Grande do Sul State, and had the following composition: Silicon 51.6%, Calcium 8.8%, Magnesium 4.4%, Potassium 0.2%, Phosphorus 1.22%.

The organic fertilizer were bovine manure and egg-laying hen manure. From 2015 to 2018 were applied bovine manure in the following rates: 17 t ha^{-1} in 2015, 24 t ha^{-1} in 2016 and 10 t ha^{-1} in 2018. Subsequently, from 2019 to 2020 were applied egg-laying hen manure, in the following rates: 5 t ha^{-1} in 2019, and 10 t ha^{-1} in in 2020. The difference on rates was established from the soil analysis result, based on indications to crops cultivated in each year. The doses were calculated to meet nitrogen, phosphorus and potassium crop demands, and were defined according to the highest nutritional requirement. The sources were distributed on the soil surface, in isolation, manually, without incorporation, due to the management of the soil in no-tillage system.

The maize (Epagri Catarina variety) was sown on 30 November 2022 in the no-till system, with 0.5 m spacing, and a population of 60,000 plants ha^{-1}. The maize harvesting was carried out on 10 June 2023, and the maize yield was evaluated.

To evaluate the soil chemical attributes, soil samples were sampled at 0-10 cm soil depth, in November 2021, six years after the first application. Each sample was composed by 8 subsamples. Samples were air-dried, sieved (2 mm) and the following chemical analyzes were carried out: pH in water, organic matter content, and calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K) and aluminium (Al) contents. The analyzes were carried out using the methodology proposed by Tedesco et al. [7].

The results were submitted to analysis of variance, the means were compared by the Tukey test at 5% probability (qualitative variable) and regression with evaluation of the predictive capacity of the proposed model (quantitative variable). All analyzes were performed using the statistical software Sisvar version 5.6 [8].

3. Results and discussion

3.1 Soil chemical attributes

The rock powder application did not change soil pH. However, we observed reduction of active acidity (pH in water) when organic fertilization was performed (Table 1). These results can be associated to the pH of organic manure utilized, that is close to the neutrality, which was also verified by Gotz et al. [3]

Tab. 1 – Effect on active soil acidity in function of organic fertilizer application, regardless of rock powder rate.

Organic fertilizer	pH in water
With	4.9 a*
Without	4.4 b

*Means followed by distinct letters in the column differ by the Tukey's test ($p<0.05$).

The application of increasing rock powder rates, associated or not to organic fertilizer, did not influence organic matter content, as well as soil Ca and Mg content (data not shown).

Relative to P content, it was not observed influence of the rock powder rates in this variable. The same result was verified by Gotz et al.[3]. According to Gotz et al. [6], this is associated to the slow solubilization of the rock powder. On the other hand, organic fertilizer increased soil P content (Table 2), because P is one of the main nutrient present in organic fertilizers.

Tab. 2 – Soil phosphorus (P_2O_5) contents with and without organic fertilizer application, regardless of rock powder rates.

Organic fertilizer	P_2O_5 (mg dm^{-3})	Availability interpretation class**
With	8.9 a*	Medium
Without	2.4 b	Very low

*Means followed by distinct letters in the column differ by the Tukey's test ($p<0.05$). ** Availability interpretation class according to the Liming and Fertilization Manual for the States of Rio Grande do Sul and Santa Catarina [9].

For soil K content, we observed an interesting effect when rock powder was applied or not. When rock powder was applied, without organic fertilizer, in increasing rates, it reduced K availability in the soil (Figure 1). It is possible that the higher active acidity observed without organic fertilizer application (Table 1) reduced the amount of pH-dependent negative charges in the exchange complex (colloids), resulting in greater mobilization of K beyond 0-10 cm depth.

On the other hand, combining different rates of rock powder with organic fertilizer increased the soil K content (Figure 2). Grosseli [10] also observed an increase in soil K content when rates of rock powder (basalt: 0, 2.5, 5 and 7.5 t ha^{-1}) associated with different rates of biochar (0, 6, 12 and 18 t ha^{-1}) were applied. According to this author, the best result obtained was the combination of 7.5 t ha^{-1} of rock dust with 18 t ha^{-1} of biochar.

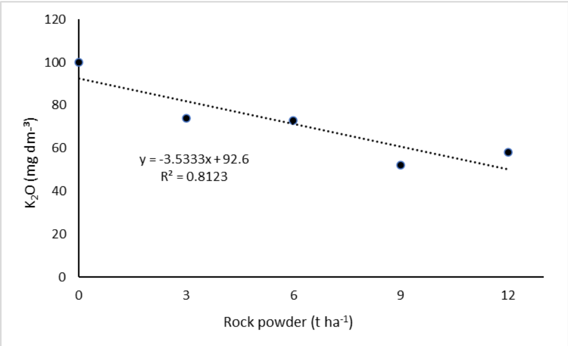

Fig. 1 – Effect of increasing rates of rock powder without organic fertilizer on soil potassium (K_2O) content.

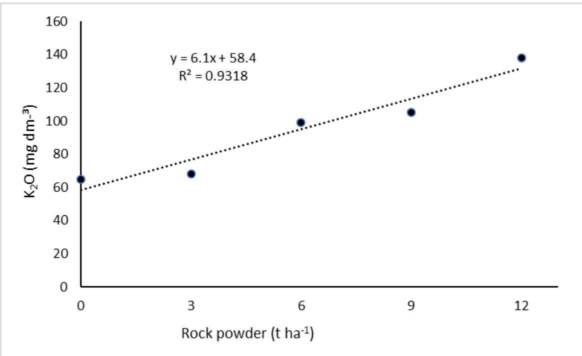

Fig. 2 – Effect of increasing rates of rock powder associated with organic fertilizer on soil potassium (K_2O) content.

Relative to the Al content, there was a reduction in the exchangeable Al content in the soil as a result of organic fertilizer application (Table 3). This effect may be related to lower active acidity, which increases the formation of Al precipitated. In addition, it may be due to the occurrence of organometallic complexes as a result of the formation of dissolved organic compounds with decomposition of the organic fertilizer.

Tab. 3 – Exchangeable aluminium (Al) content in the soil with and without organic fertilizer application, regardless of rock powder application.

Organic fertilizer	Al ($cmol_c$ dm^{-3})
With	0.56 a*
Without	0.98 b

*Means followed by distinct letters in the column differ by the Tukey's test ($p<0.05$).

3.2 Maize yield

The rates of rock powder, without organic fertilizer application, did not change maize grain yield. On the other hand, the application of organic fertilizer increased maize yield (Table 4).

The increase in maize grain yield can be partially explained by the lower soil Al content and higher soil P content when we applied organic fertilizer (Table 2, 3). Also, it should be noted the increase of soil K content when rock powder rates were applied in association with organic fertilizer, what may also have contributed to the higher maize grain yield.

Tab. 4 – Maize grain yield obtained with and without organic fertilizer application, regardless of rock powder application.

Organic fertilizer	Maize yield (kg ha^{-1})
With	7,500 a*
Without	6,480 b

*Means followed by distinct letters in the column differ by the Tukey's test ($p<0.05$).

Finally, these results are not only promising and encouraging but also call for deeper exploration. For example, the use of rock powder as a source of K, because, according to Cola and Simão [1], K is a non-renewable resource and needs to be used more efficiently. The cost of applying K in Brazil is very high, and the country depends almost entirely on imports of the K consumed in its territory.

4. Conclusions

The use of organic fertilizer reduced soil active acidity, increased soil P content and maize grain yield. The combination of organic fertilizer with rock powder improved K availability.

Under the conditions of this trial, the isolated use of rock powder should be discouraged. However, the combination of rock powder and organic fertilizer, among other practices, could result in beneficial effects for crops.

5. References

[1] Cola G.P.A., Simão J.B.P. Rochagem como forma alternativa de suplementação de potássio na agricultura agroecológica. *Revista Verde de Agroecologia e Desenvolvimento Sustentável*. 2012; 7(4): 15-27.

[2] Gotz L.F. *Pó de rocha como fonte alternativa para melhoria de atributos químicos do solo e do potencial produtivo da cultura do feijão em sistemas agroecológicos.* VI Jornada de iniciação científica e tecnológica, UFFS; 2016.

[3] Gotz L.F., Castamann A., Piovesan F., Anzolin B.L., Herek T.A., Mikoanski W.M., Rita Y.L. Use of rock powder associated with bovine manure in Latossolo Vermelho cultivated with wheat. *Revista Brasileira de Agropecuária Sustentável*. 2020; 9(2):131-139.

[4] Gotz L.F., Piovesan F., Castamann, A. Rock powder and organic fertilization in soil cultivated with black bean. *Scientia Agraria Paranaensis.* 2020; 19(3): 296-301.

[5] Embrapa. *Sistema brasileiro de classificação de solos.* Embrapa, Brasília; 2018. 355p.

[6] Soil Survey Stuff. *Keys to soil taxonomy.* Washington, United States Department of Agriculture, Natural Resources Conservation Service; 2014. 372 p.

[7] Tedesco M.J. et al. *Análise de solo, plantas e outros materiais.* Porto Alegre, Departamento de Solos, UFRGS; 1995. 170p.

[8] Ferreira D.F. Sisvar: a computer analysis system to fixed effects split plot type designs. *Revista brasileira de biometria*. 2019; 37(4): 529-535, dec. 2019.

[9] SBCS- Sociedade Brasileira de Ciência do Solo. Manual de calagem e adubação para os estados do Rio Grande do Sul e de Santa Catarina. Porto Alegre, Comissão de Química e Fertilidade do Solo; 2016. 376p.

[10] Grosseli M.A. Influência do uso de pó de rocha basáltica e biocarvão em latossolo vermelho distroférrico e no cultivo orgânico de *Phaseolus vulgaris* antecedido por plantas solubilizadoras. 2021. 107 f. Dissertação (Mestrado) - Curso de Programa de Pós-graduação em Agroecologia e Desenvolvimento Rural Sustentável, Universidade Federal da Fronteira Sul, Laranjeiras do Sul, 2021.