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Supervisor: Prof. Dr. Carlos Alexandre Costa Crusciol

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TÍTULO DA TESE: BASALT ROCK IN SUGARCANE GROWN IN FERRALSOLS: CHANGES IN SOIL CHEMISTRY, MINERALOGY AND MICROBIOLOGY AND IN CROP YIELD

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RESUMO

Visto o cultivo de cana-de-açúcar principalmente em solos brasileiros altamente intemperizados, é necessária uma alternativa para aumentar essa produção, renovando os solos. A remineralização consiste em adicionar rocha moída nos solos, como um condicionador de solo, fornecendo alguns minerais e elementos, além do baixo custo, as consequências desta aplicação não são totalmente elucidadas. Portanto, a hipótese deste estudo inclui o tratamento do pó de rocha basáltica, que pode melhorar o rendimento da cana-de-açúcar, os atributos químicos do solo e da planta; o pó de rocha de basalto aumenta o índice microbiano de qualidade do solo; a aplicação da rocha altera as comunidades microbianas no solo; e o intemperismo das rochas altera a mineralogia do solo. O objetivo deste trabalho foi avaliar o efeito da aplicação de pó de rocha de basalto na cultura da cana-de-açúcar, suas consequências na mineralogia e na microbiologia do solo. Apesar de não ser consistente com as quatro áreas, o tratamento de pó de rocha de basalto pode melhorar o rendimento da cana-de-açúcar, os atributos químicos do solo e o índice microbiano de qualidade do solo, mas pouco é notado nos atributos químicos da planta. A diversidade microbiana não foi a mesma para as quatro áreas, mas pode estar mais relacionada aos padrões geográficos do que à aplicação da rocha, mesmo com uma pequena mudança ocorrendo, não pode ser atribuída ao tratamento. Sinais de intemperismo foram notados, mas há dois pontos questionáveis: o tempo para ocorrer este intemperismo, pode ser mais rápido do que se pensava, e a quantidade de minerais intemperizados nesse tempo. A aplicação de pó de rocha de basalto melhora o rendimento da cana-de-açúcar, destacando-se suas mudanças mineralógicas no solo e não causa danos à diversidade microbiana do solo. A atividade microbiana e as pistas da microbiologia do solo nessas condições poderiam elucidar o motivo da melhoria do rendimento.

Palavras-chave: *Saccharum* spp., Remineralização, rochagem, produtividade de colmos, microbiologia do solo, minerais do solo

ABSTRACT

Since the sugarcane production mostly in highly weathered Brazilian soils, an alternative to increasing its yields, renewing these soils is required. Remineralization consists in add milled rock into the soils, as a soil conditioner, providing some minerals and elements. Besides the low cost, the consequences of their application are not totally elucidated. Therefore, the hypothesis of this study include the basalt rock dust treatment can improve the sugarcane yield, soil and plant chemical attributes; basalt rock dust increases the microbial index of soil quality; the rock application change microbial communities in the soil; and the rock weathering change the soil mineralogy. The aim of this study was evaluate the effects basalt rock dust application on sugarcane crops its consequences in soil mineralogy and microbiology. Despite not consistent to the four areas, basalt rock dust treatment can improve the sugarcane yield, soil chemical attributes, and microbial index of soil quality but a little is noticed in plant chemical attributes. The microbial diversity was not the same to the four areas, but it can be more related to geographical patterns than rock application, even with a little shift occurring, it cannot be attributed to the treatment. Weathering signals were noticed but there are two questionable points: the time to occur this weathering, may be quicker than it was thought, and the amount of weathered minerals. Basalt rock dust application improves sugarcane yield, it was notable its mineralogical changes in the soil and it does not cause damages to the soil microbial diversity. The microbial activity and footprints of soil microbiology in these conditions could elucidate the reason why occurred the yield improvement.

Keywords: *Saccharum* spp., remineralization, rocks for crops, stalk yield, soil microbiology, soil minerals

SUMMARY

GENERAL INTRODUCTION

Sugarcane is the base of one of the major export commodities in Brazil with ethanol and sugar as products, and energy as a principal by-product. Its production in 2018/2019 harvest reached 616 million of tonnes harvested from 8.4 million hectares (CONAB, 2019), resulting in a yield average of 73 tonnes per hectare, and this is the main concern of sugarcane production in Brazil, since there are reports the potential of production is around 300 tonnes per hectare.

In general Brazilian soils are highly weathered, then they are commonly composed by quartz [SiO_2], kaolinite [$Si_2Al_2O_5(OH)_4$], gibbsite [$Al(OH)_3$], hematite [Fe_2O_3], and Goethite [$FeO(OH)$], among others, varying depending on the concentration and the fraction. Specifically Ferralsols contain low availability of Si content, compared to newer soils (TISDALE et al., 1985).

One of the ways to replace those minerals in highly weathered soils is to add milled rocks from diverse sources and components. In soil remineralization, rocks chemical components need to weathering acting to be released from the minerals to soil replacement and to become available to plants and soil organisms. Temperature, water, wind and microorganisms activity are some chemical, physical and biological weathering agents' examples. These rocks contain Si, Ca, Mg, Fe, some trace elements, which can work as growth factor to microorganisms, and heavy metals which can shift the soil chemistry and consequently, biology.

The biogeochemical activities of the microorganisms in the soil are governed by indigenous microbial communities, temperature, pH, soil water capacity, among other environmental conditions, and the soil nutrients availability is the result of biological transformations (WAKSMAN; GERRETSEN, 1931; SCHMIDT et al., 2011).

The nutritional requirement of sugarcane encompass the sixteen nutrients, essential for growth of all plants, as C, H, and O (non-mineral nutrients), primary nutrients (N, P, and K), secondary nutrients (Ca, Mg, S), trace elements (Zn, Cu, Fe, Mn, Cl, B, and Mo), and the beneficial element: silicon (Si) (CALCINO et al., 2018).

Silicon function in plants is related to protection against abiotic and biotic stresses, including reports about its positive effects in chemical and physical soil attributes and it can reach, consequently 17 to 30 % yield improvement (MATICHENKOV; CALVERT, 2002). In the soil, silicate ion neutralize the toxic Al and

compete with phosphate ion for the adsorption sites in ion exchange complex in the soil, dislocating P to the soil solution (PRABAGAR et al., 2011; CASTRO; CRUSCIOL, 2013; EPSTEIN; BLOOM, 2005; POZZA et al., 2007).

Therefore, the hypothesis of this study include the basalt rock dust treatment can improve the sugarcane yield, soil and plant chemical attributes; basalt rock dust increase the microbial index of soil quality; the rock application change microbial communities in the soil; and the rock weathering change the soil mineralogy.

The aim of this study was evaluate the effects basalt rock dust application on sugarcane crops its consequences in soil mineralogy and microbiology.

FINAL CONSIDERATIONS

Despite not consistent to the four areas, basalt rock dust treatment can improve the sugarcane yield, soil chemical attributes, and microbial index of soil quality but a little is noticed in plant chemical attributes.

The microbial diversity was not the same to the four areas, but it can be more related to geographical patterns than rock application, even with a little shift occurring, it cannot be attributed to the treatment.

Weathering signals were noticed but there are two questionable points: the time to occur this weathering, may be quicker than it was thought, and the amount of weathered minerals.

Basalt rock dust application improves sugarcane yield, it was notable its mineralogical changes in the soil and it does not cause damages to the soil microbial diversity.

The basalt rock, the soil environment and the plants work as a cycle, that means, the rock release some trace elements that work together to plants exudates compounds as microorganisms growth factor, then the soil microbiota communities and population increase, the rock bioweathering occurs more intensively, providing more elements and plant nutrients, always to reach a balance in the soil.

The microbial activity and footprints of soil microbiology in these conditions could elucidate the reason why occurred the enormous yield improvement.

REFERENCES

CALCINO, D.; SCHROEDER, B.; PANITZ, J.; HURNEY, A.; SKOCAJ, D.; WOOD, A.; SALTER, B. **Australian sugarcane nutrition manual.** 2018

CASTRO, G.S.A.; CRUSCIOL, C.A.C. Effects of superficial liming and silicate application on soil fertility and crop yield under rotation. **Geoderma**, Amsterdam, v.195-196, p.234-242, 2013

EPSTEIN, E.; BLOOM, A.J. **Mineral nutrition of plants**: principles and perspectives.Sunderland: Sinauer Associates, 400 p., 2005.

MATICHENKOV, V. V.; CALVERT, D. V. Silicon as a beneficial element for sugarcane. **Journal American Society of Sugarcane Technologists**, 22(2), 21-30. 2002

POZZA, A.A.A.; CURI, N.; COSTA, E.T.S.; GUILHERME, L.R.G.; MELO MARQUES, J.J.G.S.; MOTTA, P.E.F. Retenção e dessorção competitivas de ânions inorgânicos e gibbsita natural de solo. **Pesquisa Agropecuária Brasileira**, Brasília, v.42, n.11, p.1627-1633, 2007.

PRABAGAR, S.; HODSON M.J.; EVANS, D.E. Silicon amelioration of aluminium toxicity and cell death in suspension cultures of Norway spruce (*Picea abies*(L.) Karst). **Environmental and Experimental Botany**, v.70, p.266-276, 2011

SAVANT, N. K.; KORNDÖRFER, G. H.; DATNOFF, L. E.; SNYDER, G. H. Silicon nutrition and sugarcane production: a review. **Journal of plant nutrition**, 22(12), 1853-1903. 1999

SCHMIDT, M. W. I.; TORN, M. S.; ABIVEN, S.; DITTMAR, T.; GUGGENBERGER, G.; JANSSENS,I. A. Persistence of soil organic matter as an ecosystem property. **Nature** 478, 49–56. doi: 10.1038/nature10386 2011

TISDALE, S.L.; BEATON, J.D.; NELSON, W.L. **Soil fertility and fertilizers**.4.ed. New York:Mac Millan, 1985. 754p

UNICA – União da Indústria de Cana-de-Açúcar. Produção. **Unicadata**. Available in: http://www.unicadata.com.br. Access in: 18 jun 2019

WAKSMAN, S. A.; GERRETSEN, F. C. Influence of temperature andmoisture upon the nature and extent of decompositiion of plant residues bymicroorganisms. **Ecology** 12, 33–60, 1931