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APLICAÇÃO DE PÓ DE ROCHA BASÁLTICA NO CULTIVO DE CANA DE ANO

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RESUMO: O processo rochagem é conhecido pela obtenção de pó de rocha (PR), que em condições adequadas de granulometria e composição mineralógica, pode ser utilizado no desenvolvimento e crescimento das culturas. Assim, avaliou-se a aplicação de PR a lanço após o plantio de cana-de-açúcar de ano, aos 45 dias, no município de Bebedouro, SP, Brasil, com experimento em delineamento de blocos casualizados, contendo quatro repetições e diferentes doses de PR: 0,0; 2,5; 5,0; 7,5 e 10,0 t ha^{-1}, em um Argissolo Vermelho-Amarelo eutrófico - PVAe, seguido dos tratamentos culturais padrão da propriedade, além de uma redução de 20% na adubação mineral de cobertura. Foram realizadas medições não destrutivas das características agronômicas da cultura: número de perfilhos por metro (NP m^{-1}), altura de planta (ALT), diâmetro do colmo (DC) e índice de área foliar estimado (IAFE). Os valores médios obtidos foram submetidos à análise de variância, teste de comparação de médias e regressão polinomial das doses, usando software estatístico. Com os resultados observados, a aplicação de PR proporcionou maiores valores médios, em comparação com o tratamento sem PR (controle/padrão), para tais variáveis, concluindo-se que o pó de rocha basáltica estudado contribuiu para o desenvolvimento e crescimento inicial da cultura, e que após seu registro, pode atuar como remineralizador de solos.
PALAVRAS-CHAVE: *Saccharum officinarum*, remineralizador, agrominerais silicáticos.

APPLICATION OF BASALT ROCK POWDER IN YEAR CANE CULTIVATION

ABSTRACT: The rock stone process is known for obtaining rock dust (RD), which under appropriate conditions of granulometry and mineralogical composition, can be used in the development and growth of crops. Thus, the application of RD was evaluated by broadcast after planting of year-old sugarcane, at 45 days, in the municipality of Bebedouro, São Paulo State, Brazil, with an experiment in a randomized block design, containing four replications and different doses of RD: 0.0; 2.5; 5.0; 7.5 and 10.0 t ha^{-1}, in a eutrophic Red-Yellow Argisol - PVAe, followed by the standard cultural treatments of the property, plus a 20% reduction in the mineral cover fertilization. Non-destructive measurements of the agronomic characteristics of the crop were carried out: number of tillers per meter (NP m^{-1}), plant height (PLANT HT), stalk diameter (SD), and estimated leaf area index (ELAI). The mean values obtained underwent analysis of variance, comparison of the means test, and polynomial regression of doses, using statistical software. With the observed results, the application of RD provided higher average values, compared to the treatment without RD (Control/Standard), for such variables, concluding that the basalt rock dust studied contributed to the development and initial growth of the culture, and that after its registration, it can act as a soil remineralizer.
KEYWORDS: *Saccharum officinarum*, remineralizer, silicate agrominerals.

INTRODUCTION

The search for sustainability in agricultural systems has led to research being developed in this area and finding solutions for a new, modern, and productive agriculture. The increase in the world population, projected for the next 30 years (2050) brings with it the need to feed more than 9.7 billion people, and that until the year 2030, there is the immense challenge of reducing the number of people hungry in the world, since for more than a decade this number has been increasing linearly (FAO, 2019). The use of products of natural origin can affect minimizing the demand for inorganic fertilizers in production systems, which is a positive fact since the acquisition and preparation of these fertilizers has a high cost. Within this premise, it is necessary to research the potential of products capable of guaranteeing agricultural processes and still maintaining the food quality of the products and by-products generated, through sustainable management. For this, it is important to consider positive actions towards the basis of production, which are the soils.

The case of processing rocks transformed into soil remineralizes, through the practice of rocking, with the obtaining of a by-product, rock dust, part of the conceptual tripod of sustainability, based on economic, social, and productive conditions, combined with new alternative sources of production for agricultural systems. The

applications of these sources of rock dust for different cropping systems gave rise to regional macrominerals, another extremely important factor in guaranteeing the production and logistics of this process.

The addition of rock dust to poorer or weathered soils is a practice for restructuring fertility. The technique of rock, soil remineralization, or petrofertilization, is based on descriptions of agroecological processes (Van Straaten, 2002). The use of rock dust makes it possible to rearrange the soil, improve its nutritional aspects, and conserve natural resources for longer periods, promoting a residual in the soil where it is applied. The application of rock dust to the soil improves soil conditions for plant growth, with increases in soil pH, CEC, and nutrient availability and reduction of aluminum saturation (Silva et al., 2013). Preliminary results show that the different types of rocks present different behaviors in terms of changing fertility levels, as well as agricultural productivity. However, all results were positive when compared to control plots. This use guarantees an increase in the availability of the main macronutrients (K, P, Ca, and Mg), contributing to the sustainability of agricultural systems, and may reduce the use or even eliminate it, about mineral fertilizers (Theodoro et al., 2013). The use of rock dust as soil remineralizes is a suitable alternative for maintaining soil fertility and thus favoring agricultural production (Manning and Theodoro, 2018) and healthy food.

Research has shown that rock dust slowly releases large amounts of nutrients to plants, which can increase the CEC of low fertility soils (Blum et al., 1989 a,b), exchangeable cation contents, and soil pH (Von Fragstein et al., 1988), with these effects being more intensive in basic volcanic rocks, such as basalt. In Germany, the application of 10 t ha^{-1} of basalt in the northern Black Forests increased Ca and Mg contents and soil pH (Hildebrand and Scharck-Kirchner 2000). Van Straate (2006) points out that in a tropical climate, the use of rock dust has great potential since the dissolution rates of minerals and the reactions between the surface of the minerals and the soil solution are increased under high temperature and regime of high humidity.

In this way, the objective of the present research was to evaluate the effect of the application of different doses of basalt rock dust (RD) by haul, after the planting of year cane, coming from mining company COPLAN - Construtora Planalto LTDA, in the region of Embaúba, State of São Paulo (SP), with characteristics appropriate granulometry, mineralogical, physical-chemical composition, for agricultural use, according to Decree Nº. 4954/2004 and Normative Instructions No. 53/2013, Nº. 05/2016, No. 06/2016, presenting itself as a possible soil remineralized.

MATERIAL AND METHODS

The experiment was carried out in an agricultural area in the municipality of Bebedouro - SP, located by the geographic coordinates: latitude 21° 0' 45.504" S and longitude 48° 37' 38.028W, with an altitude of approximately 527 meters and a climate of the type Aw, according to the Köppen classification (Setzer, 1966). A randomized block design was used, with four (4) replications and five (5) doses of basalt rock dust (RD), obtained by the rock-rock process using sieving (finished product), with the following characteristics (Figure 01).

PÓ DE ROCHA DE BASALTO - EMBAÚBA-SP								
<0,300 mm	As	Cd	Pb	Hg	SiO2	Al2O3	Fe2O3	CaO
%	ppm	ppm	ppm	ppm	%	%	%	%
75,40	<1	0,03	1,60	<0,05	49,70	12,60	14,10	10,00
MgO	TiO2	P2O5	Na2O	K2O	MnO	LOI	pH abrasão	umidade
%	%	%	%	%	%	%	-	%
5,30	1,93	0,21	2,32	1,05	0,21	1,85	9,71	1,77

Figure 01. Granulometric characterization (100% < 2.00mm), physicochemical composition, containing potentially toxic elements, 10 major oxides, LOI, abrasion pH, and humidity, according to MAPA IN n°05/2016, for basalt rock dust. UNESP, 2020.

The treatments (doses) of rock dust were added to the production pattern and cultural practices of the property, for planting and managing sugarcane of the year, characterized by the fertilization of planting with 500 kg ha^{-1} of 04-24- 06 ($N\text{-}P_2O_5\text{-}K_2O$), in 06/12/2019, and coverage with 450 and 360 kg ha^{-1} of 05-20-20 (05/03/2020), for control and treatments with RD (20% reduction in coverage fertilization), respectively. Weed control was also carried out with pre-emergent herbicides, in a single application, after planting. The doses of RD were distributed by a pendulum applicator coupled to the tractor, model Vicon®. The plots had dimensions of 13.0 m x 7.5 m, totaling five rows, considering the middle rows for analysis, and included five (5) treatments: 0.0 t ha^{-1} of RD (T1 - control), 2.5 t ha^{-1} of RD (T2), 5.0 t ha^{-1} of RD (T3), 7.5 t ha^{-1} of RD (T4) and 10.0 t ha^{-1} of RD (T5), distributed in randomized blocks, with four (4) replications. The soil used as the base for the cultivation was a Eutrophic Red Yellow Argisol - PVAe (EMBRAPA, 2018), with the following chemical characteristics (Table 01).

Table 01. Chemical analysis (macro and micronutrients) of soil before installation of the experiment. UNESP, 2020.

Prof. (cm)	pH	M.O.	P	S	Ca	Mg	K	Al	H+Al	Soma Bases	CTC	Sat.	Sat.
									SMP	S.B.		Bases	Al
	$CaCl_2$	g dm^{-3}	----------mg dm^{-3}----------					----------$mmol_c$ dm^{-3}----------				V%	m%
0-25	4,8	13,0	7,0	7,0	14,0	7,0	1,2	1,0	20,0	22,2	42,2	52,6	4,3
25-50	5,0	13,0	9,0	6,0	14,0	7,0	1,0	0,0	20,0	22,0	42,0	52,4	0,0

Prof. (cm)	Si	B	Co	Fe	Mn	Zn
	----------mg dm^{-3} ----------					
0-25	8,4	0,33	2,2	21	3,8	1,2
25-50	8,0	0,26	1,8	19	4,4	0,9

RESULTS AND DISCUSSION

With the use of the basalt rock dust (RD) studied, given by the characteristics of Figure 01, it is noted that it is a finished product with potential for registration as a soil remineralizer, according to the needs and compliance with Ministry of Agriculture, Livestock and Supply (MALS). The percentage of material passing through the 0.30 mm sieve (ABNT No. 50) above 75% is noted, with 100% of the same material passing through the 2.00 mm sieve (ABNT Nº. 10). In addition to this condition, the levels (mg kg^{-1} or ppm) of potentially toxic elements are well below those recommended by MALS, as are the minimum values of the 10 largest oxides, with a total base sum of 16.35 % and a K_2O content of more than 1.0%. This fact favors the agricultural use of this material, and it is important to adopt criteria for the distribution of doses used in different types of soils. To this end, using the Red Yellow Argisol - PVAe allowed promising results for the sugarcane crop, planted year-round, in December 2019, given by observations in its development and initial growth, 45 days after planting product application.

According to Manning (2018), when meeting the conditions for soil remineralizes, there is a determination of the dynamics of minerals and the release of nutrients from the rocks, in addition to the understanding of the processes of weathering and alteration of minerals in the soil that are fundamental to neutralize acidity in soils and act as a source of nutrients for crops. In addition to the low acquisition costs and reduction of environmental impacts caused by inorganic fertilizers and the control of an environmental liability of mining, with the use of this technology, according to Resende et al. (2006), there is a slow and gradual release of nutrients from rocks, which reduces leaching losses and favors a long-term release, with alkalizing materials acting as soil conditioners.

In Table 02, through the agronomic characteristics studied, the number of tillers per meter (NP m^{-1}) presented the highest average values for all the proposed treatments with an application of RD by broadcast, in the plots, for all the proposed treatments. blocks (which did not show statistical differences between them). Treatment 4 (T4), with a dose of 7.5 t ha^{-1}, obtained an average value of 23.19 tillers per meter, while Treatment 1 (without application of RD) provided an average value of 16.37 tillers per meter.

This determination, although early for crop considerations (due to future stabilization of stems) when we consider the spacing of 1.5 m between planting lines, allows us to estimate a satisfactory initial number of stems per hectare (ha) to raise crop productivity, with T4 corresponding to 154,600 cane stalks ha^{-1} and T1 to only 109,130 cane stalks ha^{-1}, approximately. About Treatments 2 (T2) and 3 (T3), these presented similar values, with a projection, per ha, of around 147 to 150,600 cane stalks, respectively. About T5, there was a reduction in this number, with approximately 139,530 tillers ha^{-1}, but not statistically different from the other treatments with RD, and still, demonstrating a higher mean value and significantly different from T1.

The condition given by the NP m^{-1} is an important factor in the production and longevity of the cane fields and it is expected that with the use of RD, it can be maintained during the cultivation and its possible regrowth. Regarding plant height (ALT HT), only Treatments 3, 4, and 5 presented the highest mean values, but T3 did not differ significantly from T1. This data is relevant if we consider that for future evaluations, taller plants will have stems with a greater number of internodes and, possibly, a greater weight of stems ha^{-1}. For T4 and T5, the mean values were 56.44 and 60.19 cm. If added to the NP m^{-1} data, they can guarantee a good production and better stalk stability (Table 02), during the development and initial growth of the culture.

Table 02. Mean values of the number of tillers per plant (NP m^{-1}), plant height (PLANT HT), stalk diameter (SD), and the estimated leaf area index (ELAI) at 45 days after spray application. rock dust (RD) under different doses, in-plant sugarcane (year-old sugarcane). UNESP, 2020.

Treatments[1]	NP m^{-1}	PLANT HT (cm)	DC (mm)	ELAI (cm^2)
T1 (absence of RD)	16,37b[2]	47,12b	15,00c	752,02b
T2 (2,5 t ha^{-1} of RD)	22,06a	46,75b	16,42b	986,60b
T3 (5,0 t ha^{-1} of RD)	22,68a	54,12ab	17,12ab	1160,12b
T4 (7,5 t ha^{-1} of RD)	23,19a	56,44a	17,75ab	1174,80b
T5 (10,0 t ha^{-1} of RD)	20,93a	60,19a	18,44a	1943,15a
Pr>F	0,001*[3]	0,0003*	0,0001*	0,0001*
Pr>BL	0,65ns	0,71ns	0,058ns	0,62ns
DMS	3,98	7,42	3,87	495,01
CV (%)	8,39	6,22	1,34	18,25

[1]Each Treatment consisted of broadcast applications in the plots, in year-round sugarcane.
[2]Means followed by the same letter in the column do not differ from each other by Tukey's test, at 5% probability.
[3]*, ** (significant at 5 and 1% probability, respectively); ns (non-significant).

Figure 02 (A) demonstrates the calibration of the RD dose that stood out, being 6.12 t ha^{-1}, presenting 23.56 tillers per meter (R^2= 95.52%). As for PLANT HEIGHT, given in Figure 02 (B), a linear behavior regarding the doses was observed, allowing that at the dose of 10.0 t ha^{-1} (T5) the average value of 60.09 cm (R^2 = 92.74%). Like PLANT HEIGHT, the data observed for the stalk diameter (SD) also showed the highest mean values for T3, T4, and T5, although T2 was included in the means between treatments T3 and T4 and was considered statistically superior (in mean values) and different to T1 (Table 02).

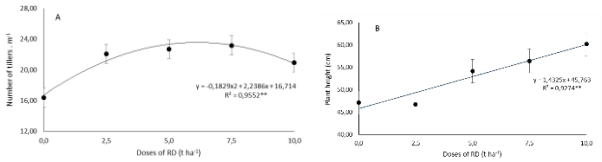

Figure 02. A. Number of tillers per meter (NP m^{-1}); B. Plant height (PLANT HT) after application of basalt rock dust doses (RD), in the development and initial growth of year-round sugarcane. UNESP, 2020.

This variable helps to increase the weight of the stalks and, through the applied doses of RD, a significant increase in DC can be observed, which is another important factor to guarantee increases in the production of this crop. T5 (10.0 t ha^{-1}) stood out from the others, presenting a DC of 18.62 mm (R^2 = 96.59%), against the only 15.34 mm given by T1 (0.0 t ha^{-1}), according to Figure 03 (A).

The estimated leaf area index (ELAI) also showed higher average values with the use of RD, but only with T5 significantly differing from the others (Figure 03 - B). The leaf area is an important agronomic characteristic since it considers the concentration of light received and that can be converted into photoassimilates for the plant in question. In the case of sugarcane, because it is a C4, in metabolic and physiological terms of energy compensation, this gain is linear, and the higher the ELAI, the greater the capacity for plant development and growth.

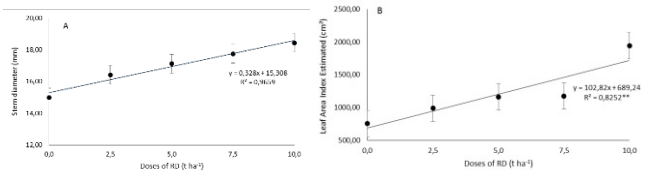

Figure 03. A. Stem diameter (DC); B. Estimated Leaf Area Index after application of basalt rock dust doses, in the development and initial growth of year-round sugarcane. UNESP, 2020.

Figure 03 highlights the dose of 10.0 t ha^{-1} (T5), which presented an average value of 1,717.44 cm^2 (R^2 = 82.52%), while T1 presented an average value of 689.24 cm^2. Thus, it is possible to observe that for the development and initial growth of the sugarcane crop, the use of basalt rock powder doses guaranteed increases in the average values of all agronomic characteristics studied. Basalt is a very important rock because the product of

its decomposition is reddish clay that originates from fertile soils (Knapik, 2005). Cristan (2002), cited by Knapik (2005), also corroborates when studying the release of nutrients from basalt dust, treating it as gradual and continuous, and that, through recent studies in Brazil, indicate it as potential recovery of pastures and cane fields.

CONCLUSIONS

Applications of different doses of basalt rock dust (RD) by hauling, after planting yearling sugarcane, at 45 days, allowed increments and increases in the average values of all agronomic characteristics evaluated, for doses above 5.0 t ha^{-1}. The RD studied contributed to the development and initial growth of the sugarcane crop, in the year planting.

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