Use of crushing residue as nutrients source in the cocoa seedlings development in Medicilândia – PA

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Abstract

The use of milled rocks has been postulated as an efficient way to provide nutrients to the plants. The objective of this work was to evaluate the cocoa seedlings agronomic performance in different Diabase Penatecaua powder treatments. The study comprehends the following phases: i) involved waste characterization, ii) treatments definition and sampling; iii) monitoring and evaluation; iv) systematization and results discussion. The experiment was realized with cocoa seedlings germinated in commercial organic substrate in the period from July to September 2019. The used rock dust was extracted at Km 85, Transamazônica highway, Medicilândia municipality – Pa. The extraction area lithology is formed by igneous rocks of Diabase Penatecaua. The experimental delineation was entirely randomized, with four repetitions per treatment, being them respectively in the dosages 0, 25, 50 and 75 (g / plant), being 16 plants per block, totaling 64 plants, and their irrigation done manually in the first hours of the day. Therefore, the results showed that the dosages were absorbed by the cocoa seedlings according to the plant's need allied to pH balance, which was caused by good nutritional cycling with the organic matter high rate present in the commercial substrate when in contact with the Diabase Penatecaua powder worked granulometry. However, the experiment time wasn't enough to obtain statistically a significant difference. Thus, it is necessary that new studies be done aiming the temporal deepening of the studied doses for the culture.

KEYWORDS: Alternative fertilizer; Fertilization; Plants nutrition; Agroecology

1. INTRODUCTION

According to the World Food and Agriculture Organization - FAO (2015), the food world production may reach four billion tons in 2025, with an average productivity of 4,5 t. ha^{-1}, when the world population might achieve the mark of 8,3 billion inhabitants, with this it is understood that there will be a greater necessity for food and with it the need of alternative options, mainly regarding disrespect to inputs that damage the soils in the long term.

The use of milled rocks has been postulated as an efficient way to provide nutrients to the plants, besides to correct deficiencies through soil remineralization. The factors that promote this practice are the

Brazilian agriculture growing demand for inputs and the economic viability due to its beneficiation low cost (MELAMED and GASPAR, 2011).

Although in 2006 the country imported 12 millions tons of matter at a cost of 2,7 billions dollars, these fertilizers present a low efficiency index being 60% for N, 30% for P, and 70% for K. This inefficiency generates a deficit on the order of 25 to 30 kg/ha of NPK leading to a greater soil impoverishment (LAPIDO-LOUREIRO et al., 2013). On the other hand, according to Fyfe et al. (2011) overcoming such limitations, the advances in rock technology may progressively contribute to maintain the health and soil fertility, ensuring food production in social and sustainable environmentally forms.

In order to reverse the current scenario, of rock powders little use and few clarifications about the subject, adopting sustainable Technologies based on agroecology, stonemeal and biofertilizers become, in this context, the viable solution for low fertility soils due to weathering periods, common situation in Brazilian soils and which contributes to the low sustainability from the agricultural practices in Brazil (THEODORO et al., 2011).

In face of information scarcity about the theme in tropical areas, the objective of this work was to evaluate the cocoa seedlings agronomic performance in different Diabase Penatecaua powder treatments

2. MATERIAL AND METHODS

2.1 STUDY AREA CHARACTERIZATION

The experiment was carried out with cocoa seedlings germinated in commercial organic substrate, in Para's Federal University facilities, Altamira Campus, with geographical coordinates Latitude: 3º 21' 18,41" South e Longitude 52º 21' 27,04" W West; altitude of 109 meters and humidity of 83% and temperatures ranging from 24 to 30°C, according to the National Institute of Meteorology - INMET (2019). The region's climate is classified as hot equatorial and humid with three dry months, it presents annual average rainfall, varying between 2000 mm and 2500 mm (IBGE, 2018).

The experimental conduction took place in the periods from July to September 2019, constituting the dry period in the region, being the months of august and september in the studied year characterized with the lowest rainfall index. The used substrate in the experiment comes from organic residues, all the process is done in Uruará county – Pará, and sold throughout Transamazônica. The material has the following chemical data:

Table 1: Substrate chemical analysis

Depth	N	P	K	H	Na	Ca	Ca+Mg	pH	Fe	Zn	Cu	M.O
cm	%	mg/dm³		%	cmol/dm³			H_2O	(mg/kg)			(%)
0,20	0,32	109	3351	111	2,45	5,34	7,53	7,42	64,4	12,2	1,9	48

Source: Fullin Laboratory

The rock powder was supplied by Rock Engineering LTDA, extracted at Km 85, Transamazônica highway, Medicilândia municipality-Pará, being acquired by fine fractions separation resulting from the rock grinding to obtain gravel for civil construction. The extraction area lithology is formed by Diabase Penatecaua igneous rocks, having its mineralogical composition being made by microscopic examination attesting 45% feldspars, 35% amphibole-pyroxene, 10% opaque, 5% micas, 5% quartz.

The interest in studying the residue utilization generated from crushing was done in order to promote economic sustainability and environmental in extraction, in addition to assess the capacity to provide nutrients and promote alternative for a region with vast cocoa potential. Below the location map from where the rock extraction

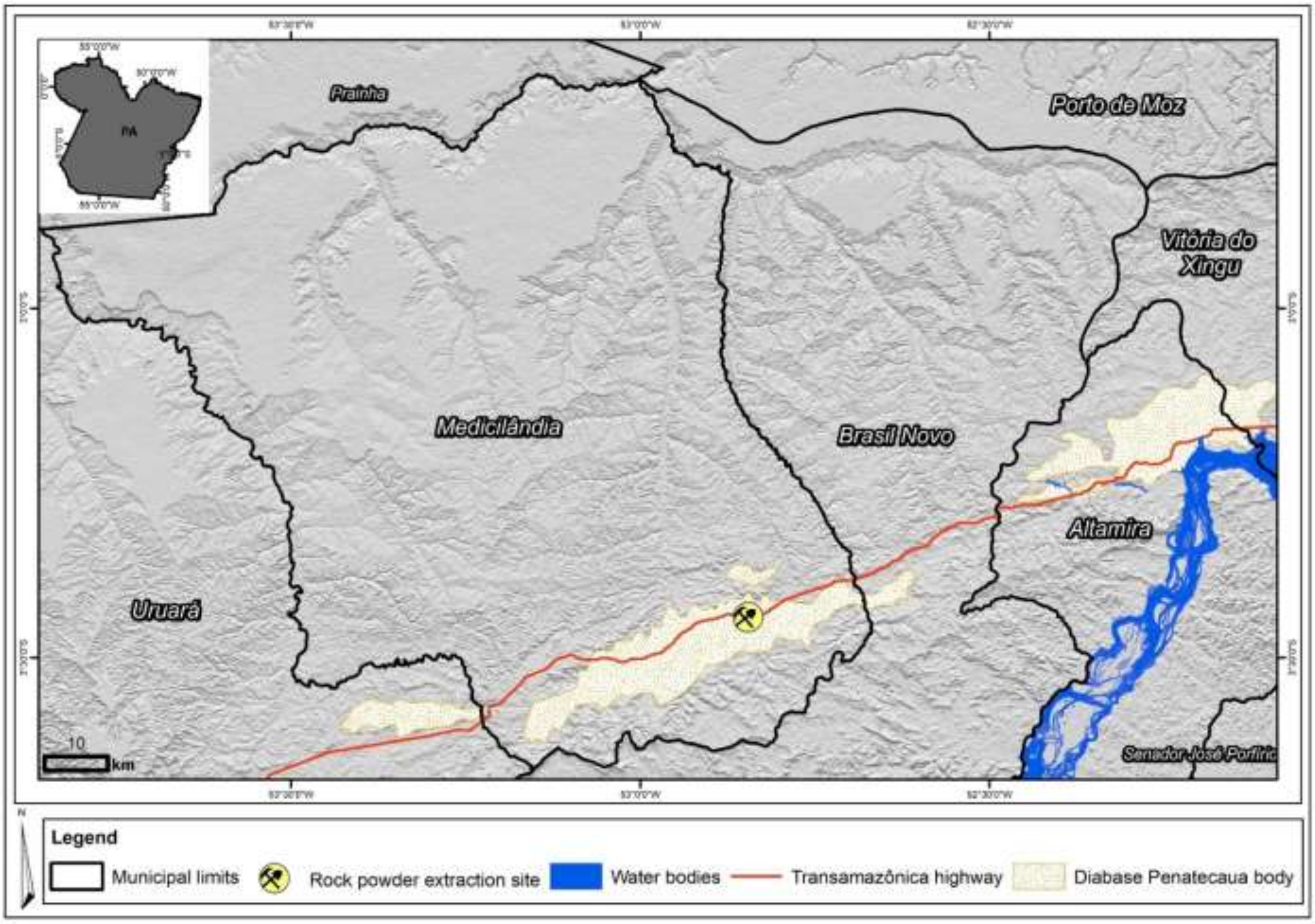

Figure 1: Location map from the Diabase Penatecaua powder extraction, km 85, transamazônica highway, Medicilândia - Pará. **Source:** Author

In the quarries, the rocks crushing basically creates five types of products: rock powder, gravel 0, gravel 1, gravel 2 and gravel 3. Of these products, the only ones that find noble applications for civil construction are gravel 1, 2 and 3. Gravel 0 and stone powder have low commercial value. Thus, with the crushing equipments evolution and in order to avoid that these fines remain stored in the quarries causing serious environmental problems, visual pollution and mainly, a lot of particulate dust in the atmosphere, it is sought its reuse for different attributions, including for stonemeal. Next, the Diabase Penatecaua powder chemical analysis used in the experiment (Table 2).

Table 2: Diabase Penatecaua Powder Chemical Analysis

pH H2O	P	K	Ca	Mg	Al	Fe	CTC	S	O. M	V
	cmolc/dm3								dag/kg	%
8,6	91	750	12,2	1,4	0,0	584	17,1	14	0,4	95,3

Source: Fullin Laboratory

The chemical analysis is done following the Embrapa recommendation (2017), where the following parameters are evaluated: phosphorus, potassium, calcium, magnesium, sulfur, sodium, zinc, iron, copper, manganese, boron, organic matter, active acidity (pH), exchangeable (Al) and potential (H+Al), in addition to sum of bases (SB), bases saturation (V), relationship between the bases, aluminum saturation (m), effective CTC (t) and CTC (T) at pH 7,0. Furthermore, it is also evaluated heavy metals contents, in order to detect their toxicity level (Table 3).

Table 3: Toxic elements analysis from Diabase Penatecaua powder.

			CONAMA 420/2009	
Parameters	**Rock powder**	**Toxicity in plants**	**Agricultural soils investigation**	**Contamination prevention**
			mg kg^{-1}	
Chrome	**0,44**	**-**	**150**	**75**
Lead	**1,58**	**-**	**180**	**72**
Nickel	**0,90**	**10-30**	**70**	**30**
Cadmium	**0,14**	**10-20**	**3**	**1,3**

Source: Plants toxicity (Alloway, 1995 apud Silva, 2018); Soil Toxicity (CONAMA nº 420/2009).

The heavy metals total concentrations analyzed (Cr, Pb, Ni, Cd) were below the Prevention Values (PV), concentration that can affect negatively the used rock powder quality, established in accordance with CONAMA nº 420/2009. In this way, the same are classified in the Quality Reference Value (QRV), being non-toxic in the detected concentrations.

2.2 METHODOLOGICAL PROCEDURES

2.2.1 **Experiment conduction in field**

The study comprehends the following phases: i) involved waste characterization, ii) treatments definition and samplings; iii) monitoring and evaluation; iv) systematization and results discussion. The same was developed with the coco aculture (*Theobroma cacao* L.), the fruits were collected in a conventional garden at Km 85, transamazônica highway, Medicilândia county - Pará. The seed preparation started on July 20th, 2019 with pulping being done using sand and paper towel moistened with water, after pulping it was dried in the shade, and taken to to a clean and sterilized plastic container for pre-germination, where it remained closed until the root system outbreak. After 96 hours of preparation, the seeds were ready for sowing (Figure 02).

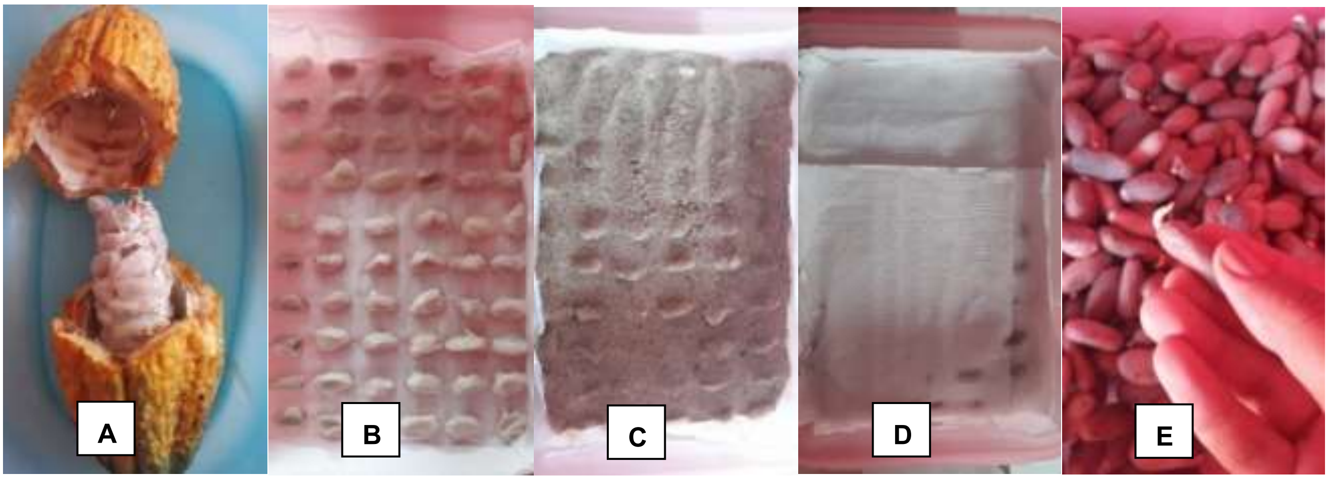

Figure 2: Cocoa fruit (A) - Cocoa seeds organized for pulping start (B) - Clean and sterilized sand application for effective pulping (C) - Paper towel insertion for success in the process (D) – Pre – germinated seeds (E)
Source: Author

The Diabase Penatecaua powder used in the experiment was supplied to the laboratory in 50 kg fiber bags, placed to dry in open air and subsequently, separated into granulometry sieves of 2.00mm, 1.00mm and finally, the used grain size which was 0.850 mm. For the efficiency in this process, the sieves were put on the digital electromagnetic stirrer (SSP-1100, SPLABOR, São Paulo, Brazil) in vibrations at 6.0, timed at one minute, for all worked treatments, this procedure was realized on July 22nd 2019. After the rock powder be with correct granulometry, it was weighed on a precision scale to be incorporated into the correct treatments and in sequence to do the sowing (Figure 3).

Figure 3: (A) - Sieve in different openings in mm for material preparation; (B) - Digital electromagnetic stirrer making the material sieving; (C) - Rock powder incorporation into the substrate; (D) – Pre-germinated cocoa seeds sowing.
Source: Author

2.2.2 Treatments and experimental delineation

The planting was done on july 24th, where the experimental units were constituted of 5x20cm plastic tubes, with approximately 500g of incorporated substrate into the rock powder. The experimental delineation was from randomized blocks, with four repetitions per treatment, being them respectively in the dosages 0, 25, 50 and 75 (g / plant), being 16 plants per block, totaling 64 plants, and its irrigation done in the early hours of the day.

The dosages were calculated in proportion to the organic substrate amount according to the container capacity. In addition, it was used the fertilization and liming recommendation manual for Pará state according to the culture specifications and having as a reference the rock powder chemical analysis.

2.2.3 Collection and processing data

The biometric data collection occurred in 30 days after the induction with the treatments, from this moment on, it was realized the measurements biweekly being evaluated the parameters height, collar diameter and leaves number, during the collection periods, totaling 45 observation days. The plants height was measured from the base to the apex tip with the assistance of a scalimeter and the collar diameter with digital pachymeter aid (200mm/8 Digimess 100.176bl), measured at the stem submersion height in the container.

It was collected all the plants and taken to the soil laboratory from the Agronomic Engineering College, UFPA/ Altamira Campus, where it was realized the measurement with Root Length scalimeter (RL) from the plants and verified the Aerial Green Mass Weight (AGMW) and Root Green Mass Weight (RGMW), after that, the contents analysis of Aerial Dry Mass Weight (ADMW) and Root Dry Mass Weight (RDMW), were stored in paper bags, and dried in a forced circulation greenhouse at 70ºC for 72 hours until the constant weight attainment.

Then it was conducted samples preparation from the leaf and root tissue, after being dry and with constant weight, they were ground in a Willey mil, and sent to the chemical attributes determination at the Agronomic, Environmental Analysis Laboratory and Chemical Solutions Preparation – Fullin in Linhares – ES.

The obtained data were tabulated and submitted to statistical analysis following the averages multiple comparison model Tukey test at 5% probability. For Diabase Penatecaua powder treatments, the evaluations were through regression analysis using the Sisvar 5.6 program.

3. RESULTS

3.1 CHEMICAL ANALYSIS

The chemical attributes determination was carried out in order to verify if the stonemeal technique caused interaction and absorption by the plant, which individually can entail in factors such as antagonism, synergism or inhibition, as shown in table 4.

Table 4: Chemical attributes average contents from the organic substrate incorporated into the Diabase Penatecaua powder

Treatment	O.M	V	pH	Al^{3+}	H+Al	m%	P	K	Ca	Mg	SB	CTC
g/plant	g kg_{-1}	%	H_2O	cmolc dm^{-3}		%	mg dm^{-3}		cmolc dm^{-3}			
0,0	16,1	80,8	6,5	0,0	2,5	0,0	102	630	5,7	2,9	10,5	13,0
0,25	12,1	86,7	7,0	0,0	2,0	0,0	135	980	7,9	2,3	13,1	15,1
0,50	9,2	86,1	7,0	0,0	1,6	0,0	120	950	5,4	1,7	9,9	11,5
0,75	9,0	85,8	7,1	0,0	1,7	0,0	123	910	5,6	2,0	10,3	12,0

Source: Fullin Laboratory

Among all the observed levels, pH is one of the most important, since from the balance of it which is possible that the plant absorbs the nutrients. For cocoa crop, the ideal variation is around 6,0 to 7,0 according to EMBRAPA (2020). It is important to note that even within the ideal parameter for the crop as the pH rises with the treatments increase, the primary macronutrients such as phosphorus and potassium that are closely linked to the plant growth also rise, this balance was due to the good nutrients cycling.

Another important factor to be considered is the organic matter content that remineralized to the rock powder causes a greater nutrients induction, resulting in a good elements cycle for the plant and also in the biggest ionic cation exchange capacity. Regarding aluminum, the fact that it is unavailable is important for acidity regulation in the process, which results in saturation percentage nullity by aluminum (m%).

Base saturation (v%) aims to identify the fertility content, being ideal for cocoa crop from 60 to 70, as pointed out in the study analysis, this increase is linked to the high organic matter content that causes a good microbial activity increasing the nutrients availability such as Ca and Mg. It is worth of mentioning that plants which have good levels of these elements have resistance to toxicity and high photosynthetic capacity (Table 5).

Table 5: Results interpretation from the analysis of organic substrate chemical attributes incorporated into the rock powder, based on the reference values from fertilization and liming recommendation manual for Pará State (EMBRAPA, 2020).

Trat.	M.O	V	pH	Al^{3+}	H+Al	m%	P	K	Ca	Mg	SB	CTC
g/planta	g kg_{-1}	%	H_2O	cmolc dm^{-3}		%	mg dm^{-3}		cmolc dm^{-3}			
0,0	E	H	A	L	L	L	E	E	H	H	H	E
0,25	E	H	A	L	L	L	E	E	H	H	H	E
0,50	E	H	A	L	L	L	E	E	H	H	H	E
0,75	E	H	A	L	L	L	E	E	H	H	H	E

L = low; A = average; H = high; E = elevated.

In order to diagnose the plant nutritional status, the plant tissue analysis was performed by Fullin laboratory following the methods recommended by USP-ESALQ, where it is determined the macro and micronutrients contents: nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, zinc, copper, manganese and boron (Table 6). ==

Table 6: Chemical attributes average levels of leaf tissue in cocoa seedlings

Content	U	Treatments				Suitable Range	
		0,0 g/plant	0,25 g/plant	0,50 g/plant	0,75 g/plant		
N	g/kg	17,99	19,11	21,56	19,39	20-25	Low
P		4,07	4,21	3,94	4,21	1,8-2,5	High
K		21,25	24,38	21,25	18,75	13-23	Average
Ca		5,55	4,93	6,71	7,55	8-12	Low
Mg		4,81	3,76	4,81	4,38	3,0-7,0	Average
S		1,24	1,24	1,64	1,37	1,6-2,0	Low
Fe	mg/kg	562	343	935	751	150-200	High
Zn		38	40	54	50	50-70	Low
Cu		15	19	11	21	10-15	High
Mn		74	64	75	42	150-200	Low
B		43	36	39	30	30-40	Average

Source: Fullin laboratory; Fertilization and liming recommendation manual for Pará State, (EMBRAPA, 2020).

Thus, we have that the time factor (45 days) in this experimental period resulted in pH balance, making the seedlings only absorb the necessary for their development. However, it would be needed more time for externalization of nutrient availability degree, resulting that the minimum period to work with Diabase Penatecaua doses in cocoa seedlings is 45 days.

In addition, there was a visual difference in the leaves number, where it is possible to verify that as the treatments increase, it occurs a decrease in them. Also, it was noticeable to identify that the collar diameter from the treatments 0,25 (g/plant) and 0,50 (g/plant) became thinner. As shown in figure 4.

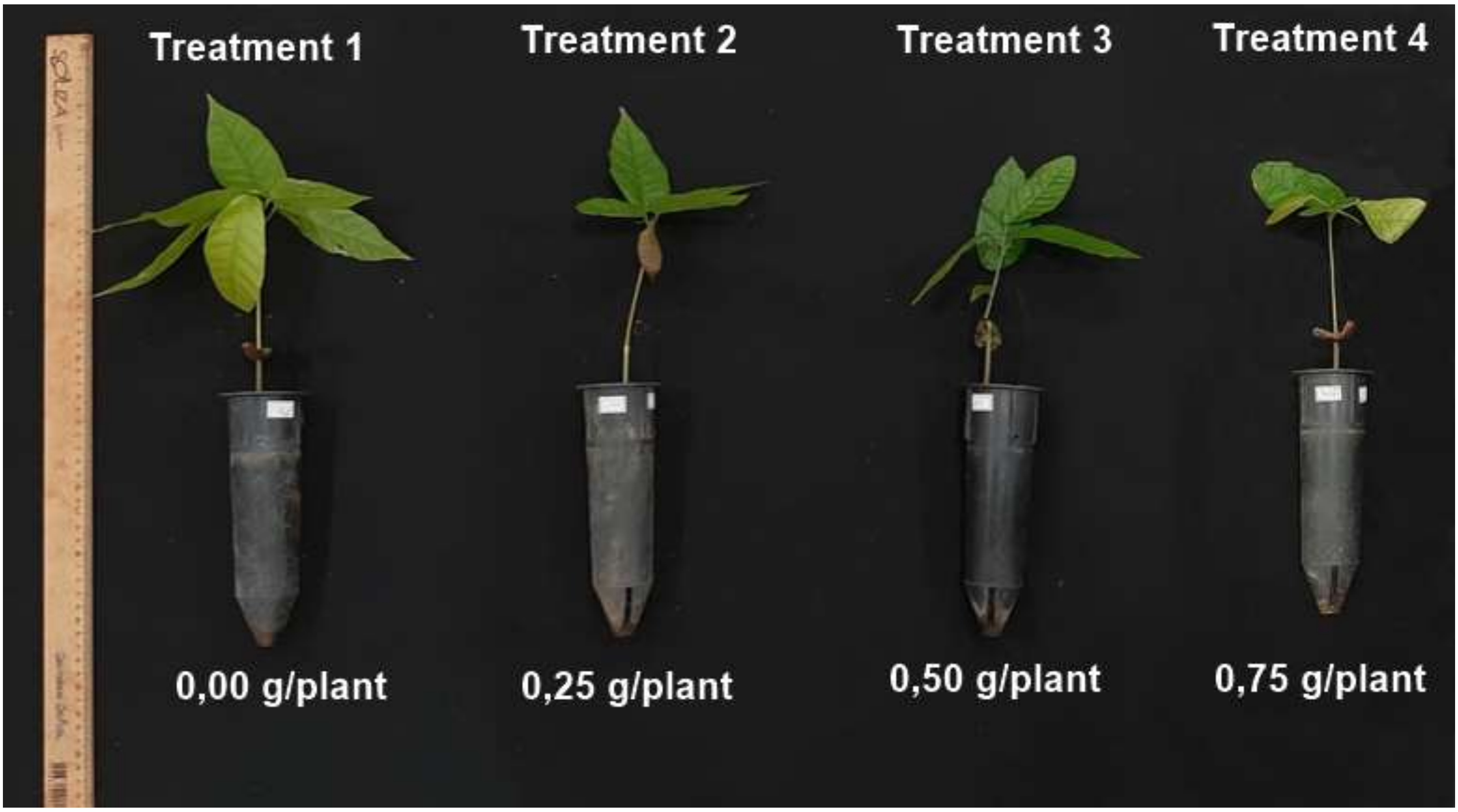

Figure 4: Visual analysis from different treatments of Diabase Penatecaua powder in cocoa seedlings developed in tube-type containers.

3.2 STATISTICAL ANALYSIS

Below, it is found the Variance Analysis data (ANAVA) represented by the mean square values and significance levels in function of the used treatmentswith a significant effect at 5% probability ($p < 0.05\%$) on the variables (Table 7).

Table 7: Variance Analysis Values (ANAVA) with variation sources, freedom degree (D.F), the mean square values and the respective height significance (H); collar diameter (CD); leaves number (LN); Root; Aerial green matter weight (AGMW); Root green matter weight (RGMW); Aerial dry matter weight (ADMW) and Root dry matter weight (RDMW).

VARIATION SOURCE	D.F	H	C.D	L.N	CR	AGMW	RGMW	ADMW	RDMW
Treatments	3	4.306^{ns}	0.014^{ns}	0.494^{ns}	3.030^{ns}	0.594*	0.144^{ns}	0.087*	0.015^{ns}
Blocks	3	2.175^{ns}	0.041^{ns}	1.277^{ns}	4.694^{ns}	1.288*	0.047^{ns}	0.048*	0.001^{ns}
Error	9	1.555	0.013	0.409	0.823	0.155	0.151	0.014	0.004
Total	15	-	-	-	-	-	-	-	-
CV (%)	-	9.32	3.24	12.89	6.69	12.06	27.23	13.38	19.44

*significant at 5% probability; ^{ns} non significant.

The observed values below show significant data for tested dosages in results of AGMW and ADMW, as for the other parameters, the results revealed not significant, in which it accepts the nullity hypothesis, according to the Tukey test, a significant difference at 5% probability (p> 0.05%). For the variable aerial green matter weight (AGMW), the dosage 0.50 (g / plant), which differs from the others, showing to be higher. Consequently, the Aerial Dry Matter Weight (ADMW) also obtained the same difference for the same dosage (Table 8).

Table 8: Readings for the unfolding of medium-sized rock dust treatments - Height (H), Collar diameter (CD), leaves number (LN); Root length (RL); Aerial green matter weight (AGMW); Root green matter weight (RGMW); Aerial dry matter weight (ADMW) and Root dry matter weight (RDMW).

INDEPENDENT VARIABLE	TREATMENT (g/plant)			
	0	0,25	0,50	0,75
Height (H)	14.585^{a1}	13.917^{a1}	12.605^{a1}	12.437^{a1}
Collar Diameter (CD)	3.557^{a1}	3.505^{a1}	3.575^{a1}	3.610^{a1}
Leaves Number (LN)	5.325^{a1}	5.200^{a1}	4.700^{a1}	4.625^{a1}
Root Length (RL)	14.105^{a1}	12.730^{a1}	12.925^{a1}	14.500^{a1}
AGMW	3.690^{a1}	3.345^{a1}	3.757^{a2}	3.310^{a1}
RGMW	1.715^{a1}	1.322^{a1}	1.335^{a1}	1.247^{a1}
ADMW	1.090^{a1}	0.952^{a1}	1.877^{a2}	0.735^{a1}
RDMW	0.422^{a1}	0.400^{a1}	0.325^{a1}	0.292^{a1}

a1 = doesn't differ; a2= differs; Significant difference by the Tukey test at 5% probability.

The Tukey test was done to compare the tested treatments, the same is based on the Significant Minimum Difference (SMD) in order to verify which dosage had synergy with the cacoa seedlings. With this, it was possible to observe that even with the green and dry matter reduction for the treatment of 0.50 g / plant, it is still not possible to define an adequate dosage, since the other results do not differ statistically from the check.

When the treatments are quantitative, with more than two levels, it is also used the regression analysis, which establishes a function between the dependent variable (measured in the experiment) and the independent variable (applied treatment) as shown in figure 5.

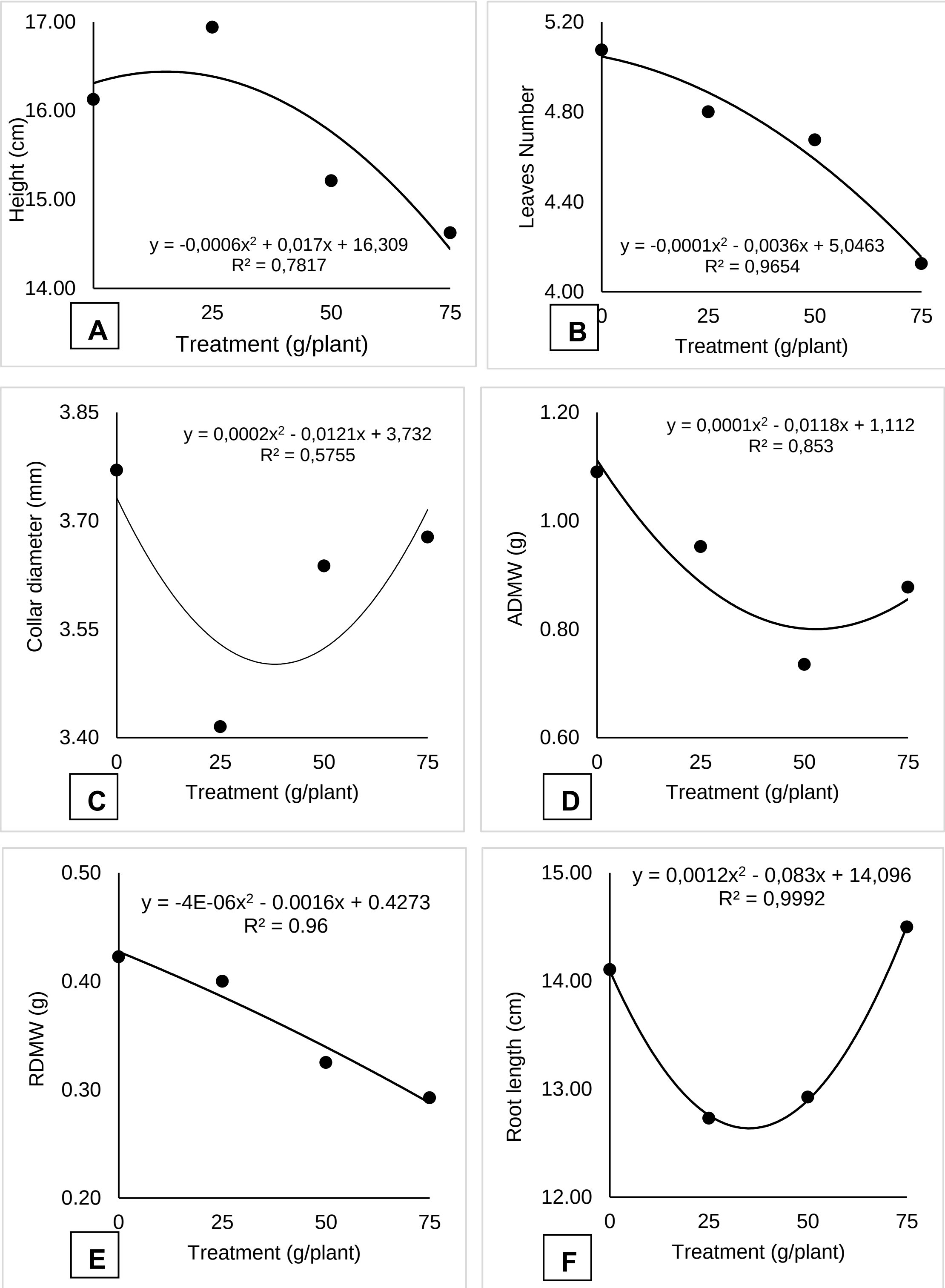

Figure 5: Height (A); Leaves Number (B); Collar diameter (C); Aerial Dry Matter Weight (D); Root Dry Matter Weight (E); Root Length (F). Significant at 5% probability.

The treatments increase provided a negative correlation, that is, the higher rock powder doses in tube-type containers favored a lower height and consequently a smaller leaves number corroborated by the visual analysis. Furthermore, there was no significant correlation for root length, aerial dry matter weight and root dry matter weight when compared to the studied check. It was only possible to identify that for the collar diameter in the treatments 0,25 (g/plant) and 0,50 (g/plant) there was a difference in becoming thinner than the others, which was also confirmed in the visual analysis.

As already mentioned, and also to the fact that it is common that some rocks types may not provide good results for the applied culture, generating a decrease effect of some evaluated factors, causing the need for more experimental tests and further research.

4. DISCUSSION

Before being adopted the worked dosages, it was necessary an extensive study from the rock dust chemical elements, since, according to Grecco et al., (2013), the rocks chemical and textural composition is a lot varied in terms of mineral species. Each mineral has a dynamic release of the constitution elements which is conditioned by weathering processes that will be submitted when applied. In order to potentialize the particular lithology effect for the stonemeal, it is essential that the minerals identification and chemical composition analysis be realized according to Theodoro et al., (2011). Another factor that must be considered is the crop’s nutritional demand, in which, the treatment to be applied of milled rock can be correctly dimensioned (BAMBERG et al., 2011).

As presented, the adopted granulometry was not sufficient for full externalization by the seedlings, however, the nutrients absorption by the culture, was observed in the leaf tissue chemical analysis, and it is corroborated by Pandolfo and Tedesco (1996), who says that the agronomic efficiency of each rock type depends, among other factors on the adequacy of its granulometry, which is, in most cases, directly related to nutrients release. In some, the nutrients availability such as Ca and Mg can be very fast when the material is finely milled. The author also highlights that the absorption time on the part of some crops is less than one month, which is not the case from the cocoa culture, in which even though the agromineral synergy with the plant occurs, the 45-day time was not enough for its full externalization.

Moreover, Theodoro et al., (2011), make it clear that the rock powders potential use has been reinforced by the organomineral mixtures usage, where the bacterial biological activity, originating from organic matter, plays a special role in the nutrients release from rocks, more quickly. This argument is signed by Hinsinger et al., (2001), who points out that the organisms action present in organic material can modify its chemical characteristics until plant effective induction with rock powder. Therefore, the used organic substrate was indispensable for the nutrients cycling present in the rock powder, which were efficiently detected in the leaf tissue of the cocoa seedlings.

According to, Deleito et al., (2009), the advantage of organic substrates use for nutritional supply, is linked to the fact that it can be found as commercial products, or even produced by the own farmer. As a result, the rock powder usage promotes, among other benefits, the capacity increase of ionic cation exchange when incorporated into organic materials.

Still in relation to the chemical elements study present in the rock powder, it is important to emphasize the fact that it does not have any aluminum content, which is a known nutrient for making acid Amazonian soils. This characteristic is quite common according to realized studies by Kautzmann et al., (2011); Nunes, (2012), in which rock powder samples from Nova Prata municipality - RS didn't provide aluminum for the soil. That is, the studied agromineral becomes of great value for farmers present in the Amazon.

With the pH balance, the plant only absorbed the sufficient for its development, however, it was perceptible the aerial green matter weight increase and consequently of aerial dry matter that was possibly due to the high potassium content present in the rock powder, even getting at the suitable level was reinforced for this result. The researcher Filho et al., (2006) observed the same increase in the rice dry matter production after the potassium silicatic rocks use finely milled and incorporated.

Silva et. al., (2013), also obtained similar results where he attested using basalt powder the potassium (K) content release coming from potassium micas and still observed that the stimulus to microbial activity helped in the release of this element and of magnesium (Mg). It is also known that microorganisms have a fundamental role, mainly in tropical environments, in rocks solubilization (NAHAS, 1999; SANTOS, 2002).

The adopting feasibility of this practice is important when it comes to productivity increase, since, the cocoa is a big vector for the agrobusiness development in Pará, a fact that was approached in a study done in the State by Firmino et al., (2013) on the potential for sedimentary rocks stonemeal, where it obtained that in the municipalities of Itaituba, Altamira, Monte Alegre and Alenquer, it is found the main sedimentary rocks containing phosphorus, which is the second most commonly nutrient applied to crops. Moreover, the author highlights the crops importance such as cocoa in the agricultural regions from lower Amazon and Xingu, and of forest planting programs, with the biodiversity conserving objective in the surroundings of these regions, as well as in transamazônica.

The same study also points out the importance of the exploitation place be close to the consumer source, mainly family farming centers. This argument is also reinforced by the author Theodoro et. al., (2011) who says that stonemeal is an important agroecological practice that can drastically reduce the production costs in that the product derived from the rock, depending on the transport distance, costs between 20 and 30% of the conventional product, allowing the small producer to optimize the production process and foster local economies.

The adoption of this practice by family farming is widespread for the other Brazilian regions. Almeida et. al., (2009) reports the use experience of basalt powder in the agroecological production systems with family farmers in south Paraná and norte catarinense plateau, which was based on the participative methodology of the agroecological knowledge construction and had as mobilizing theme the basalt powder use in the soils fertility recovery. In this research, it was done the basalt powder use associated with green manure, and the local seeds usage. These mechanisms are fully anchored by agroecological principles. According to the farmers' reports, systematized by Almeida, the production systems have obtained good productivities, low production cost, high reduction, or elimination, from the pesticides use and greater resilience.

In addition, the soluble fertilizers have high costs associated with beneficiation and transport over long distances, which can create environmental problems such as surfaces water eutrophication and subsurfaces or polluting gases release into the atmosphere (Tilman et al., 2001; Martins et al., 2010). Studies carried out by Theodoro et al., (2011) indicate that the costs for rock powders acquisition are about 60 to 70% lower than the conventional inputs. Theodoro et al., (2011), mentions that it does not require chemical attacks and concentration processes, in many cases they are ready for use and production costs are minimal, when considered an available residue in local extractive mines or wastewater from mining activities.

5. CONCLUSIONS

The results showed that the dosages were absorbed by the cocoa seedlings according to the plant's need allied with pH balance, which was caused with the good nutritional cycling due to the organic matter high rate present in the commercial substrate when in contact with the worked granulometry from Diabase Penatecaua powder. The experiment obtained significant results for the variable Aerial Green Matter Weight (AGMW) and Aerial Dry Matter Weight (ADMW) for the dosages of 0,50 (g/plant), which differs from the others, being higher, according to the Tukey test at 5% probability ($p > 0.05\%$). The visual and regression analysis pointed out a difference in the leaves number, where it is possible to verify that as the treatments increase, it occurs a decrease in them. Also, it was noticeable to identify that the collar diameter from the treatments 0,25 (g/plant) and 0,50 (g/plant) became thinner. However, it is necessary that new studies be carried out aiming the temporal deepening of the studied treatments for the culture in question.

ACKNOWLEDGMENTS

Pará’s Federal University and Rock Engineering LTDA.

BIBLIOGRAPHIC REFERENCES

Alloway, B. J (1995) Metais Pesados em Solos**.** Blackie Academic and Professional, Chapman and Hall, Londres, 368 p.

Almeida, E.; Pstersen, P. e Silva, F. J. P. (2009). Lidando com extremos climáticos: análise comparativa entre lavouras convencionais e em transição ecológica no Planalto Norte de Santa Catarina. Agriculturas v. 6, n.1.

Bamberg, A.L., Silveira, C. A. P., Potes, M. L., Pillon, C.N., Louzada, R.M., Campos, A. A. Dinâmica de liberação de nutrientes disponibilizados por diferentes tipos de rochas em colunas de lixiviação. Anais do Congresso brasileiro de ciência do solo, 33., 2011. Uberlândia, MG, 2011.

Brasil. Conselho Nacional do Meio Ambiente – CONAMA. Resolução Nº 420, de 28 de dezembro de 2009.

Deleito, C.S.R. et al. Sucessão microbiana durante o processo de fabricação do biofertilizanteAgrobio. In: FERTBIO, 2009, Santa Maria. Anais Santa Maria: Soc. Bras. de Ciências do Solo e da Sociedade Brasileira de Microbiologia, 2009. CD-ROM.

Embrapa, Amazônia Oriental – Livro Técnico – Recomendação de Adubação e Calagem para o estado do Pará, Belém PA (Brasil), 2020. 262p.

Food and Agriculture Organization of the United Nations - FAO. Statistical Databases. Agriculture. 2015. (http://www.fao.org/corp/statistics/en/) Acessado em 09/03/2021

Filho, M. P. B.; Fogeria, N. K.; Santos, D. F.; Couto P. A.; 2006. Aplicação de rocha silicatica como fonte alternativa de potássio para a cultura do arroz de terras altas. Espaço & Geografia, Brasília, Vol.9, Nº 1, 63:84.

Firmino, C. C. Jr. et al., Potencial para rochagem de rochas sedimentares da bacia do amazonas no Pará. Anais do II Congresso Brasileiro de Rochagem, p. 160-167, 2013.

Fyfe, W.; Leonardos, O. H.; Theodoro, S. C. H. Sustainable farming with native rocks: the transition without revolution. Anais da Academia Brasileira de Ciências, v.4, p.715-720, 2011.

Grecco, M. F. Desempenho agronômico de fontes minerais e orgânicas de nutrientes para as culturas de milho e trigo. Anais do II Congresso Brasileiro de Rochagem, p. 24-31, 2013.

Hinsinger, P.; Barros, O. N. F.; Benedetti, M. F.; Noack, Y.; Callot, G. Plant-induced weathering of a basaltic rock: experimental evidence. Geochimica et Cosmochimica Acta, 65: 137–152, 2001.

Instituto Brasileiro De Geografia E Estatística - IBGE. Mapa do clima do Brasil, Rio de Janeiro, 2018. (http://geoftp.ibge,gov.br/informacoes_ambientais/climatologia/mapas/brasil/Map_BR_clima_2018.pdf.) Acessado em: 10/02/2020

Instituto Nacional de Meteorologia - INMET – Estação Meteorologica de Observação de Superfície Automática, 2019 – (http://www.inmet.gov.br/portal/index.php?r=estacoes/estacoesautomaticas) acessado em: 18/06/2019.

Kautzmann, R. M. et al. Caracterização do pó de rocha da britagem de basaltos na região da APL Basaltos Nova Prata-RS, para aplicação em Rochagem. Relatório parcial do projeto CNPq nº. 550203/2011-7, 24 p., 2011.

Lapido-Loureiro, F. E.; Melamed, R.; Figueiredo Neto, J. (eds.) (2011). Fertilizantes: Agroindústria e Sustentabilidade. Rio de Janeiro, RJ: Centro de Tecnologia Mineral, CETEM/ PETROBRAS, 656 p.

Marques, J. J. et al. Major element geochemistry and geomorphological relationship in Brazilian Cerrado soils. Geoderma, Amsterdam, v. 119, n. 3/4, p. 179-195, Apr. 2004.

Martins, E. S. Uso potencial de rochas regionais como fontes de nutrientes e condicionador do solo. Jataí: EMBRAPA Cerrados, 2010. (http://www.redeaplmineral.org.br/biblioteca/eventos/1b0-seminario-apl-do-sudoeste-goiano/08%20-%20Palestra%20Eder%20Martins.pdf). Acessado em: 10 mar. 2020.

Martins, E.S.; Resende, A.V.; Oliveira, C.G.; Furtini Neto, A.E. Materiais silicáticos como fontes regionais de nutrientes e condicionadores de solos. In: Fernandes, F.R.; LUZ, A.B.; Castilhos, Z.C. (Eds). Agrominerais para o Brasil. Rio de Janeiro: CETEM/MCT, 2010. 380p.

Melamed, R.; Gaspar, J. C.; Miekeley, N.; Pó de rocha como fertilizante alternativo para sistemas de produção sustentáveis em solos tropicais. Série estudos e documentos. Brasília: CETEM/MCT, 2011.

Nahas, E. Solubilização microbiana de fosfatos e de outros elementos. In: Siqueira, J. O.; et al. (Eds.). Interrelação fertilidade, biologia do solo e nutrição de plantas. Lavras: Universidade Federal de Lavras, 1999. p. 467-486.

Nunes, J. M. G. 2012. 95 f. Caracterização de resíduos e produtos da britagem deRochas basálticas e avaliação da aplicação na rochagem. Dissertação de Mestrado. Programa de Pós- Graduação do Curso de Avaliação de Impactos Ambientais em Mineração / Centro Universitário La Salle – Unilasalle.

Pandolfo, C. M.; Tedesco, M. J. Eficiência relativa de frações granulométricas de calcário na correção da acidez do solo. Pesquisa Agropecuária Brasileira, Brasília, v. 31, n. 10, p. 753-758, 1996.

Santos, K.S. 2002, 68 f. Atuação de fosfato natural com adição de enxofre com Acidithiobacillus na solubilização de fósforo e no desenvolvimento de sabiá (Mimosa caesalpiniaefolia) em solo de tabuleiro. Dissertação de Mestrado, Universidade Federal Rural do Pernambuco, Recife.

Silva, L. D. P. Ação de microrganismos em pó de basalto. Anais do II Congresso Brasileiro de Rochagem, p. 43-50, 2013.

Theodoro, S. H., Leonardo, O. H. e Almeida, E. (2011). Mecanismos para disponibilização de nutrientes minerais a partir de processos biológicos. Brasília. Embrapa. p. 173-181.

Tilman, D.; Fargione, J.; Wolff, B.; D'Antonio, C.; Dobson, A.; Howarth, R.; Schindler, D.; Schlesinger, W.H.; Simberloff, D.; Swackhamer, D. Forecasting agriculturally driven global environmental change. Science, 292: 281-284, 20