EFFECTS OF STONEMEAL WITH ORGANIC FERTILIZATION ON TROPICAL SOILS

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Abstract

This paper presents partial results of research whose main goal is to investigate the potential of using rock dust for soil remineralization. Five types of rocks were evaluated (kamafugite, carbonate-bearing mica schist, hydrothermal metamorphic rock, fresh basalt and weathered basalt) with, or without, the addition of organic compost (bovine manure). Experimentation took place near the city of Planaltina, in the Federal District area of Brasilia, Brazil. Testing occurred over a two-year period on five agricultural crops (corn, beans, garlic, carrots and okra), on a minimum of two harvests, using crop rotation. Preliminary results show that different rock types present different behaviors in regards to varying fertility levels, as well as agricultural productivity. Nevertheless, all results were highly positive when compared to control plots. The rock type that showed the highest level of performance was carbonate-bearing mica schist. Despite this, plots containing only stonemeal showed superior productivity compared to control plots. Furthermore, fertility parameters (pH, Cation Exchange Capacity and Total Organic Capacity) also underwent positive alteration through rock use. The availability of key macronutrients (K, P, Ca and Mg) increased in all plots. These indicators show that the use of stonemeal for food production in tropical soils may contribute to

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the eradication of poverty and food sovereignty in Brazil, as well as ensure food production without the use of chemical fertilizers.

Key words: stonemeal, agroecology, remineralization and sustainability..

Introduction

The major challenges faced in ensuring the maintenance of life on Earth are food production and conservation of natural resources, especially soil and water. The use of increasingly specialized technologies, highly dependent on knowledge, fertilizers and mechanized implements make agricultural activity an extremely risky and expensive business venture. These facts limit technological applications by small-scale farmers.

The record harvests obtained each year in Brazil come with the side effects of a greater reliance on fertilizers. The majority of these fertilizers, approximately 70%, are imported. Other side effects include an increase in erosive processes, due to lack of soil conservation and management techniques applications.

In order to counter such barriers, the use of accessible low-impact technologies, as well as incorporating new technological approaches is necessary, especially for farmers who wish to uphold sustainable practices. Remineralization is a fertilization technique defined by the practice of rejuvenating low fertility soils (Kromberg et al, 1987). Aiming to reverse the excessive use of soluble fertilizers, remineralization technology rests on principles of sustainability and consists of adding certain rock powders into soil. Due to its especially low cost, this technique represents a viable and economically feasible option for small-scale farmers (Theodoro, 2000).

Adding stonemeal to leached soils enables remineralization through the addition of a large amount of macro and micronutrients lost to weathering or anthropogenic processes (Formoso., 2006; Leonardos et al., 1976, 1999; Theodoro e Leonardos, 2011. Theodoro, et al., 2013). This resource, both naturally and generously available throughout the planet, behaves as a nutrient bank, in both multi-nutrient and agro-mineral forms.

Furthermore, the addition of rock dust facilitates a rearrangement of the soil's physical characteristics, promoting a change in soil porosity and permeability parameters (permoporosity or effective porosity). This feature is in line with the notion developed by Petersen and Almeida (2008), who maintain that we should not think of soil fertility only in terms of the supply of available nutrients, but within a strategic context that encompasses the development of self-reproductive methods, such as biological nutrient recycling and conservation of natural resources.

Cost, equally as important as aspects of soil nutrition and rearrangement, and therefore fertility and the conservation of natural resources, is another factor worth consideration. Research by Theodoro et al. (2000, 2009) indicates that the cost of acquiring rock dust is approximately 60 to 70% lower than traditional fertilizers. In addition to cost, Brazil possesses immense geodiversity throughout its territory, guaranteeing an occurrence of a wide range of rock types suitable for this purpose, such as basalts, kamafugites, carbonatites, phonolites, serpentinites, schists, phyllites, marls, certain granites and gneisses.

Methodology

The experimental site, established in 2011, is located on the experimental field of the Federal Institute of Brasilia's School of Agroecology, in the suburban town of Planaltina within the Federal District. The experimental site coordinates are 25º 23'S and 51º 30'W, at 1,026 meters of altitude. The climate is tropical, with two well-defined seasons. The dry season lasts from April to September, and the wet season from October to April, with an average annual precipitation between 1,200 and 1,700 millimeters. The soil classified as Oxisol (EMBRAPA, 2006). Researchers completed the methodological procedures at various stages in the following format:

(a) selection of rock types;
(b) collection, grinding, quartering and splitting of samples into various parts for different types of analysis;
(c) identification of abrasion pH;

(d) Geochemical characterization of selected rocks;
(e) Petrographic description of rocks;
(f) Characterization of clay minerals or secondary minerals through X-ray diffraction;
(g) Pedological study of soils - secondary data;
(h) Analysis of soil fertility and of rocks with three different extractor types (Mehlich – HCl 0.05M + H2SO4 0.0125M, citric acid at 2% and oxalic acid 5%);
(i) Measurement of macronutrients (P, K, Ca and Mg) and micronutrients (B, Zn, Cu, Mn and Fe), both promptly available through reading of the results in ICP (inductive coupled plasma);
(j) Measurement of organic material levels by colorimetric method;
(k) Measurement of potential acidity and the CEC (Cation Exchange Capacity) in Calcium acetate at pH 7.0;
(l) Implementation of mechanically prepared and completely randomized designed plots, with 6m2 plots and four repetitions. Since the tests were performed simultaneously with three crops, the total experimental area of was 1,402 m2, considering the 138 plots and the spaces between them;
(m) Twelve treatments types were implemented. Five rock types were used, kamafugite, carbonate-bearing mica schist, hydrothermal metamorphic rock, fresh basalt and weathered basalt. Researchers tested plots with and without the addition of organic compost, obtained through bovine manure, as well as control plots and plots fertilized with organic compost only. The proportion of rock and compost was 1:2, following indications of previous research (5 t/ha. of rock dust and 10 t/ha. of organic compost), which equaled to 3 kg of rock and 6 kg of compost per plot. Integration of rock dust and compost, or a mixture of both, was completed by broadcasting over top soil levels;
(n) Researchers named the treatments in the following manner: testimony/ control (T); organic compost (OC); hydrothermal metamorphic rock (HR); mica schist (X); kamafugite (K); fresh basalt (fB); weathered basalt (wB); metamorphic hydrothermal rock + compost (HR+C); mica schist + compost (X+C); kamafugite + compost (K+C); fresh basalt + compost (fB+C); weathered basalt + compost (wB+C). Figure 1 displays the delineation of the area in schematic form;

(o) Spreading of ground hay straw mulch aimed at reducing the occurrence of spontaneous or invasive species, as well as the need for irrigation and maintenance of soil humidity[5];

(p) Monitoring of plant development;

(q) Systematic management and control of invasive plants;

(r) Plant harvests;

(s) Separation of roots, fruits and aerial or straw parts;

(t) Comparison of root development (size and quantity);

(u) Standardization of yield data (weight, product quality, and comparison of the various treatments);

(v) Production of histograms, charts and comparative yield tables in relation to regional and national yield averages;

(w) Systematic repetitions and periodical analysis of soil fertility to determine the changes in fertility profiles and the possible assimilation of nutrients derived from rock dust as well as in alteration of quantity of available organic material, besides the profile of soil acidity.

[5] After planting of the first crop, an intense infestation of an invasive species occurred, common to degraded areas, coco-grass (Cyperus rotundus L). Control of coco-grass in the corn plants took place manually and on a regular basis. However, carrot had to be replanted and beetroot was substituted by okra. Researchers used tree marigold (Tithonia diversifolia) and elephant grass (Pennisetum purpureum) as mulch covering to control infestations. This allowed for control of the invasive species and facilitated the addition of another nitrogen source for the soil.

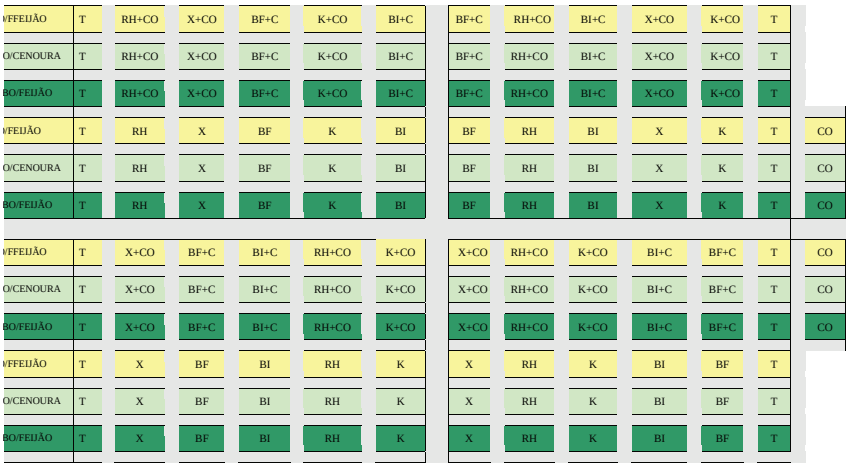


Figure 1. delineation of the testing/treatment area
T: control; X: schist; RH: hydrothermal metamorphic rock; fB: fresh basalt; wB: weathered basalt; K: kamafugite.

Discussion of Results

Experimentation showed positive results. After one-and-half years of testing with all five crops involved and five different types of rock dust, with or without organic fertilizer mixture, results indicate that the use of different rock dusts can supply necessary nutrients required by these cultures.

The petrographic analysis revealed that the tested rocks consisted of the following minerals: basalts (occurred plagioclases, pyroxenes, vitreous material and zeolites); hydrothermal metabasic rock (pyroxenes, feldspars, apatites and carbonates); kamafugite (olivine, pyroxenes and phlogopites, immersed in a matrix of olivines, diopside, perovskite, richterite, kalsilite, apatite, melilite and zeolites); and carbonate bearing mica schist (muscovite, chlorite, dolomite, albite and quartz). Supplementary X-ray diffraction analysis to identify minerals altered by weathering processes showed that the basalts were composed mostly of smectites, plagioclase and augite. Quartz was present, but at a lesser constituent in fresh

basalt. The kamafugite possessed significant quantities of smectites, carbonates and hydroxyapatite. Oxisols in the area are composed of kaolinite, gibbsite and goethite.

As expected, the five rock types, which vary in nutrient offerings, presented different results in terms of changing soil fertility levels and productivity. However, in all the cases, productivity of the various plots was superior to the control plots. The mica schist showed the best results for the production of garlic, beans and okra. The kamafugite provided better results for corn, and hydrothermal metamorphic rock showed better results with the carrot crop. Organic compost mixture improved yield performances in corn, beans, carrots and okra. Garlic was the exception, as the best yields occurred in the plots without organic compost. However, it is important to note that plots containing only rock dust produced yields superior to those obtained in the control plots (Figure 02).

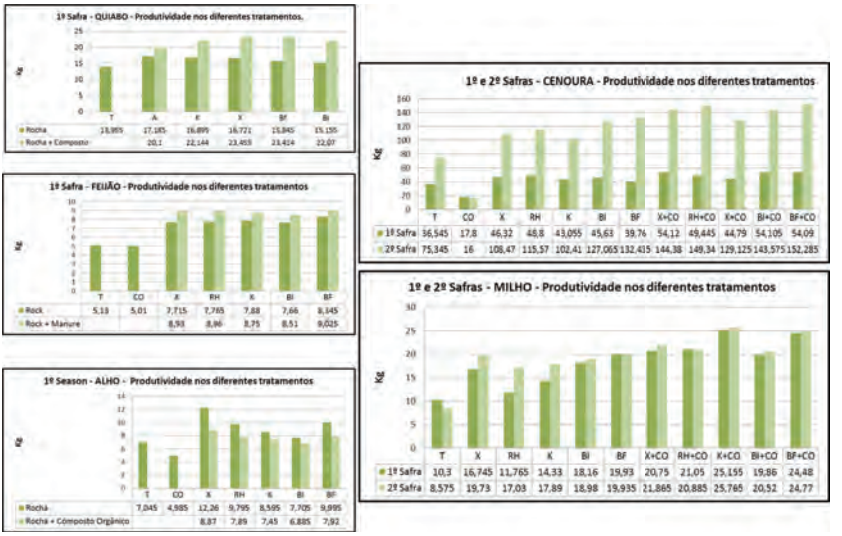
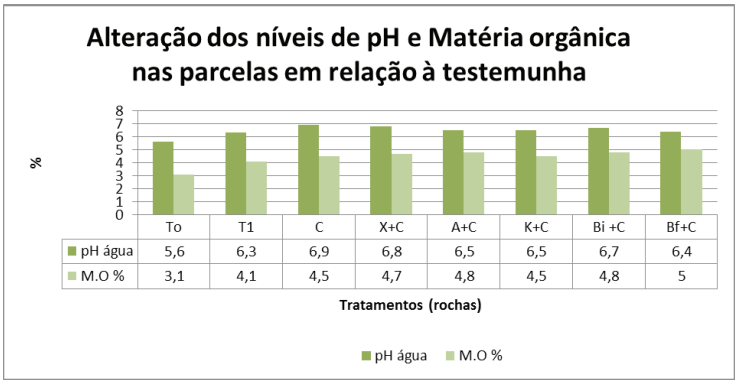


Figure 2. Yields of crops evaluated according to the different treatments in the first harvest (corn, beans, okra, garlic and carrots).

The second harvest produced superior corn and carrot yields. Due to irrigation problems during the flowering period, okra and bean crops fell during second harvest. Garlic yield results are not yet final. Despite irrigation problems that masked the results, rock dust improved the performance of the five tested crops, even in cases with no addition of organic compounds.

"Rock dust use also positively altered pH and total organic material in fertility parameters (Figure 3). The availability of principal macronutrients K, P, Ca and Mg increased in all plots, indicating that interaction of rock dusts with soil and plants occurs rapidly, especially when organic material is available (Figure, 04).



	To	T1	C	X+C	A+C	K+C	Bi +C	Bf+C
pH água	5,6	6,3	6,9	6,8	6,5	6,5	6,7	6,4
M.O %	3,1	4,1	4,5	4,7	4,8	4,5	4,8	5

Figure 3. Change in the pH and the organic material levels after 18 months of treatment applications

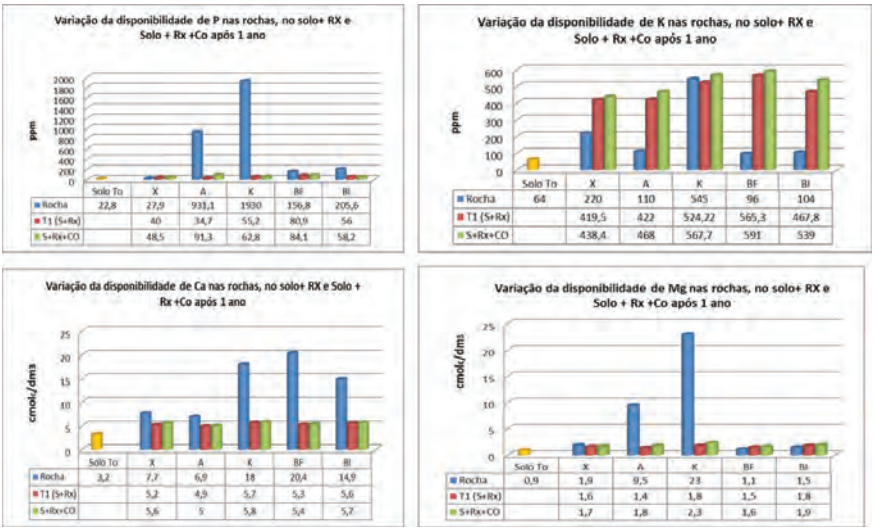


Figura 4. Change in the availability of the principal macronutrients (K, P, Ca and Mg) in the control plots, in the plots of soil+rock, and of soil+ rock +compost

Data analysis concludes that after a year of rock/soil interaction, the availability of principal macronutrients could occur over a longer period than that analyzed, given the available amount in the rocks is superior to that found in the soils. Furthermore, it is possible that the addition of organic compost increased the macronutrient supply of the rocks, possibly due to the action of acids and microorganisms in this type of material.

The sum of the petrographic, pedological, fertility and X-ray diffraction analyses provided important indicators as to the potency of different rocks on different crops. Therefore, this indicates that rocks rich in potassium and calcium, such as mica schists and kamafugites, best suited for bean, garlic, okra and corn crops. While hydro thermals, rich in P and Ca, showed superior association with carrot crops. Both weathered

fresh basalts showed equally interesting performances for all crops, but especially with corn and beans. These indicators require further study because the influence of organic materials, such as tree marigolds and ground elephant grass, contributed to the collection of results.

Conclusions

Achieving productivity levels that are compatible with averages obtained in conventional cultivation is certainly a strong indicator of the potential of stonemeal soil fertilization according to varying crop standards. Results of all evaluated parameters confirm that the mineral nutrients present in rocks can satisfy the nutritional necessity of soils for different crops. Above all, such results guaranty that Brazil has at its disposal alternatives to diminish dependence on imported chemical fertilizers, which are expensive and concentrated within few countries. The abundance of rocks in different regions of Brazil guarantees the obtainability of food and energy production through sustainable methods. Although this topic encompasses economic perspectives, it is primarily applicable to the issue of food sovereignty in Brazil, with the added advantage of producing healthy foods without the use of chemical fertilizers.

Acknowledgements

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