BONE MEAL AND OYSTER BARK AS SOIL ACIDITY IMPROVERS

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ABSTRACT

Objective: The objective of this study was to evaluate the potential of bone meal and oyster flour as soil acidity correctors and to obtain the acidity neutralization curve of soil samples from a dystrophic yellow latosol in the eastern Amazon.

Method: The capacity of the materials as acidity correctors was evaluated. To obtain the acidity neutralization curve, the materials were mixed into samples of 2 kg of soil, in doses of 2, 3, 4, 5 t ha⁻¹ for oyster flour and bone meal. The soil mixture and material remained incubated for a period of 45 days, the pH of the soil in its suspension with water being measured every 15 days within that period. The data obtained were submitted to regression analysis, adjusting the equation for estimating the pH value according to the dose of material applied.

Result and conclusion: One of the materials evaluated has promising potential as a soil acidity corrective in the period of 45 days compared to limestone.

Implications of the research: Research has been carried out with some solid materials that show the capacity for correcting the acidity of the soil, such as alternative correctives to limestone, because of the high quantity in which they are discarded in the environment.

Originality/value: In search of a more sustainable and productive agriculture, there is the need to find effective alternatives for the correction of the acidity of the soils, also aiming at the recovery of waste that would normally end up in the garbage.

Keywords: Residues, Liming, Alternative Improvers, pH increase.

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A FARINHA DE OSSO E A CASCA DE OSTRA COMO CORRETIVOS DA ACIDEZ DO SOLO

RESUMO

Objetivo: Objetivou-se, com a realização deste trabalho, avaliar a potencialidade da farinha de ossos e farinha de ostras como corretivos da acidez do solo e obter a curva de neutralização da acidez de amostras de solo de um latossolo amarelo distrófico na Amazônia oriental.

Método: Avaliou-se a capacidade dos materiais como corretivos da acidez. Para a obtenção da curva de neutralização da acidez, os materiais foram misturados em amostras de 2 kg de solo, nas doses de 2, 3, 4, 5 t ha⁻¹ para a farinha de ostra e farinha de ossos. A mistura de solo e o material permaneceu incubada por um período de 45 dias, medindo-se de 15 em 15 dias, dentro desse período, o pH do solo na sua suspensão com água. Os dados obtidos foram submetidos à análise de regressão, ajustando-se a equação de estimativa do valor de pH em função da dose de material aplicada.

Resultado e conclusão: Um dos materiais avaliados possuem promissor potencial como corretivo da acidez do solo no período de 45 dias em comparação ao calcário.

Implicações da pesquisa: Pesquisas têm sido realizadas com alguns materiais sólidos que apresentam capacidade de correção da acidez do solo, como corretivos alternativos ao calcário, em razão da elevada quantidade em que são descartados no ambiente.

Originalidade/valor: Em busca de uma agricultura mais sustentável e produtiva, há a necessidade de encontrar alternativas eficazes para a correção da acidez dos solos, visando também o aproveitamento de resíduos que normalmente iriam parar no lixo.

Palavras-chave: Resíduos, Calagem, Corretivos Alternativos, Elevação do pH.

1 INTRODUCTION

The current environmental pressure, in relation to the unbridled deforestation of the Amazon region, has induced the search for productive solutions, from the agricultural point of view, as a way of reducing the opening up of new areas in the region. In this context, the adoption of technologies that guarantee the optimization of the production systems used, in areas already deforested, requires the use of appropriate agricultural practices, such as the rational application of corrective measures to raise the productivity of crops to economically satisfactory levels, so as to allow the intensification of the use of cultivated areas and reduction of pressure on the forest (CRAVO et al., 2009).

In the Amazon region, the soils have low natural fertility and high acidity under these conditions, the production of most crops is limited, which makes it indispensable to correct the acidity of the soil by means of liming to obtain satisfactory productivity (MOREIRA et al., 2000). Soil acidity limits agricultural production in significant areas of the world, including in tropical areas, due to toxicity by Al³⁺ and/or Mn²⁺ and/or low levels of Ca²⁺ and Mg²⁺, which causes low base saturation. These factors limit cell division, the growth and deepening of the root system, the availability of nutrients and biological activity, which affects both the establishment and the development of crops. Under these conditions, the application of limestone is the most economical, fast and efficient means of solving these problems, because it raises the pH, increases the negative charges in the exchange complex, decreases the solubility of Aluminum and increases the retention of cations (ERNANI et al., 2000). Correcting soil
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Acidity is the most efficient way to eliminate chemical barriers to the full development of roots, ensuring efficient use of water and nutrients and, as a result, provides greater crop production. Many materials can be used to correct acidic soils among them oyster flour, which has 38% Ca in its mineral composition and has neutralizing power, as well as calcium-rich Bone Flour, in addition to having about 2% nitrogen and 27% phosphorus.

Agriculture uses inputs such as fertilizers and soil improvers to meet the nutritional requirements of crops. Alternatives to management must then be found, taking into account the existing limitations in the area (DE MATOS & CORTEZ, 2023). The substitution of limestone by alternative residues in the correction of soil acidity becomes interesting option, since it allows its harmonious disposal in the environment, besides economy and environmental preservation with the decrease in the extraction and use of limestone (MONACO, 2012). The chemical composition of oyster and bone meal shows high levels of calcium and magnesium (BORON et al., 2004 and BENCHIMOL et al., 2006), indicating the potential use of these residues as soil acidity correctors. However, little reference is found in the literature on the use of these materials for soil acidity correction. Considering the lack of work on the association and use of oyster and bone meal for the correction of acidity and soil fertility, as well as the need to combine agronomic and environmental interest, this work aims to evaluate the effects of the use of oyster meal and bone meal as a function of doses and incubation time in the soil in the correction of soil acidity.

2 LITERARY REVISION

2.1 Soil Acidity

The majority of the soils in Pará are acidic, that is, they have a high concentration of hydrogen and/or aluminum ions in the soil. The acidity of the soil promotes the appearance of toxic elements to plants (Al) and causes the decreased availability of nutrients for them. The consequences are the damage caused by low crop yields. Therefore, the correction of the acidity of the soil (liming) is considered as one of the practices that contributes most to the increase of the efficiency of fertilizers and consequently of the productivity and profitability of farming. The range of pH desirable for optimal plant growth varies between plantations. While some grow better in the 6.0 to 7.0 range, others grow well in slightly acidic conditions. Soil properties that influence the need for and response to lime vary by region.

Knowledge of the soil and the plantation is important in managing the pH of the soil for better plantation performance. Soils become acidic when basic elements such as calcium, magnesium, sodium, and potassium retained by soil colloids are replaced by hydrogen ions. Soils formed in conditions of high annual rainfall are more acidic than those formed in more arid conditions. Therefore, most soils in the Amazon Southeast are inherently more acidic than those in the Midwest and Far West. Soils formed in low-rainfall conditions tend to be basic with soil pH readings around 7.0. Intensive cultivation for several years with hydrogen or manure fertilizers can result in soil acidification. In the wheat-growing regions of Kansas and Oklahoma, for example, which have soil pH of 5.0 and below, the toxicity of aluminum in wheat and the good response to sludge have been documented in recent years.

2.2 Limestone and Soil Acidity

Limestone is a sedimentary rock composed of calcium and magnesium carbonate, extracted from deposits and widely used in agriculture to neutralize soil acidity. The incorporation of limestone into the soil is called liming. In addition to correcting soil acidity, liming provides the macronutrients calcium (CaO) and magnesium (MgO), neutralizes the toxic...
Phytotoxic effect of aluminum and manganese, and enhances the effect of fertilizers. The liming results in increased productivity and competitiveness. The main objectives of liming are: to eliminate acidity from the soil and provide calcium in magnesium supply to plants.

Calcium stimulates root growth and therefore with liming occurs the increase of the root system and a greater exploitation of water and soil nutrients, helping the plant in tolerance to drought. Liming also has other benefits, such as: increasing the availability of phosphorus, as it decreases the soil fixation sites; decreasing the availability of aluminum and manganese through the formation of hydroxides, which are not absorbed; increasing the mineralization of organic matter with consequent greater availability of nutrients and favoring the biological fixation of nitrogen. In the physical properties of the soil, liming increases aggregation because calcium is a flocculent cation and thereby decreases compaction.

2.3 Bone Flour

The bones consist predominantly of hydroxyapatite, which can decompose under the action of heat into tricalcium β-phosphate, CaO and water (TSUYOSHI et al. 1999). In addition to the presence of calcium and phosphorus, the bones have small amounts of other ions in their composition, such as sodium and potassium, and, depending on the wash, Fe from the blood (MIYAHARA et al. 2007). Regarding use in agriculture, historical records show that bones were the first phosphate fertilizers and widely used in Europe during the 19th century (UNIDO 1998). John (1840) reported that in the 18th century farmers in Sheffield and Yorkshire (England) used ground bones discarded by bone and ivory taps in agriculture. When the supply of animal bones declined in Europe, human bones were collected from battlefields or cemeteries, for use in agriculture, and by 1830, treatment of bones with sulfuric acid was a common practice (UNIDO 1998).

The process of making bone meal requires the cooking stage with digesters (which can be replaced by "cauldrons", for smaller amounts of raw material) or autoclaves, and subsequent percolation with steam heating (PACHECO, 2006). The high energy cost of the processing makes it difficult to reuse animal carcasses that, in places without an infrastructure for grease, are discarded without adapting to environmental standards and supervision by the public sector. A low-cost, easy-to-implement alternative that can be realized in the absence of grease infrastructure is the production of bone ash from beef carcasses coming from slaughterhouses and butchers, exposed to burning. This is a cheap and accessible technology for rural producers, which could reduce the waste of materials, with potential agricultural reuse.

2.4 Oyster Bark Flour

Shell flour or shell limestone, as it is also called, is a soil acidity improver, as well as rock limestone, virgin lime, hydrated lime or dolomitic limestone, however, as it provides calcium and magnesium and is of animal origin, however it should be considered as natural organic fertilizer. Shell flour is obtained by grinding the fossilized stones of marine animals’ shells, containing 96% calcium (calcium carbonate) and 0.3% magnesium (magnesium oxide). In addition, it has lasting effect and has slow release. The material in these shells is rich in calcium carbonate, and can be reused for agriculture and industry, that is, a destination that is nobler than disposal. Calcium carbonate is used in pulp, compact marble for flooring and coatings, fertilizers, ceramic industry, bricks, paints, polymer load, among others (BOICKO, 2007). In Brazil, there are few studies on the viability of taking advantage of this residue. In Korea, since the 80s, research has been carried out for the use of oyster shells, due to the great productivity in this country.
Korean researchers Yoon et al. (2002), researched the possibility of replacing cement aggregates with ground oyster shells by mixing them with sand. The mixture was considered efficient and a good alternative in cases of sand scarcity. Also in Korea, studies have shown that pyrolysis of shells at a temperature of 750 °C for one hour, in a nitrogen atmosphere, results in a product for removing phosphates in waste water, with an efficiency of over 98%, constituting an alternative for eutrophication of waters (KWOM, 2004). Calcium carbonate is therefore a suitable solution for most acidic soils. According to corrective manufacturers using shell limestone, shells are more efficient in productivity and profitability due to the physical and chemical differences between shell and rock limestone. The former has a porosity of 10.6%, compared to 5.9% of the rock, making it a contact surface many times larger, which contributes to the increase in solubility, going so far as to be the shell ten times more soluble than the rock. Thus, the shell limestone is used quite successfully, applying in small quantities and on the day of planting.

3 MATERIAL AND METHOD

The work was carried out in a vegetation house of the Institute of Agrarian Sciences - ICA of the Federal Rural University of Amazonia - UFRA, located in the municipality of Belém (PA), in the period from September 2016 to October 2016. The soil was collected at depths of 0.0 to 0.20 m. It is placed to dry, then sieved on 5 mm sieves. The experimental design was entirely casualized, distributed in factorial scheme 3 x 4 with four repetitions, being the factors: three corrective (oyster flour, bone meal and limestone) and four doses, each corrective (2, 3, 4 and 5 t ha⁻¹). The soil of the experimental area was classified as dystrophic Yellow Latossolo, according to the Brazilian Soil Classification System (EMBRAPA, 2006). Soil incubated for 45 days and assessed at 15 days to assess soil pH behavior. As a control treatment, commercial dolomitic limestone was used, with 96% PRNT, following the same dosages applied in the other correctives. The experiment was composed of 48 vessels (experimental units) with a capacity of 4 dm³. The need for soil water was carried out in order to keep it close to field capacity, thus facilitating the action of the soil improver. During performance of the work the soil was turned up daily.

4 RESULTS AND DISCUSSION

Significant effects occurred depending on the correctives applied, with isolated effects and highly significant differences noted at 15 days of experimental driving. For the following periods (at 30 and 45 days), highly significant differences were observed both for the interaction between treatments and in isolation (Table 1).

<table>
<thead>
<tr>
<th>F.V.</th>
<th>G.L.</th>
<th>15 days</th>
<th>30 days</th>
<th>45 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrective (C)</td>
<td>2.</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Doses (D)</td>
<td>3.</td>
<td>**</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>C x D</td>
<td>6</td>
<td>Ns</td>
<td>**</td>
<td>**</td>
</tr>
<tr>
<td>Error</td>
<td>36</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C.V.</td>
<td>47</td>
<td>6.12</td>
<td>5.57</td>
<td>5.55</td>
</tr>
</tbody>
</table>

** - Significant (p<0.05); * - Significant (pDAR<0.01); ns - not significant.

Source: Authors

4.1 Effect of Treatments on the pH (H₂O) of the Soil at 15 Days of Experimental Driving

Doses and correctives presented significant effect in an isolated manner (p<0.01). The use of bone meal did not have a significant effect on pH elevation at all doses applied. However,
oyster flour and limestone showed differences, and better results were observed for the fourth dose in both sources. With regard to the different corrective sources, similar results were noted between the limestone and oyster flour, except for the second dose which differed statistically, with the limestone providing the best pH results (Table 2).

Table 2 - pH results as a function of the application of doses and corrective agents at 15 driving days.

<table>
<thead>
<tr>
<th>Corrective</th>
<th>Doses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 t ha⁻¹</td>
</tr>
<tr>
<td>Bone meal</td>
<td>4.29Ab</td>
</tr>
<tr>
<td>Oyster flour</td>
<td>4.69Ba</td>
</tr>
<tr>
<td>Limestone</td>
<td>5.05Ba</td>
</tr>
</tbody>
</table>

Capitals, horizontally, compare the doses within each treatment. Small letters, vertically, compare each dose between treatments.

Source: Authors

It is observed that at 15 days of soil incubation, the highest pH value (5.87) by the limestone corrective action was observed at a dose of 5 t ha⁻¹. For oyster flour, this pH value was 5.58 also achieved at the dose of 5 t ha⁻¹ (Table 2).

The highest pH results achieved at 15 days of incubation reached the range considered ideal for most agricultural crops (5.5 to 6.5). It is possible that the application time was sufficient for the reaction of the material in the soil, corroborating with obtaining pH values closer to neutrality.

Neto et al. (2015) studying the recovery of boron in the presence and absence of liming, observed increase in pH after 15 days of incubation of the soil with limestone.

AIRES et al. (2014) working with burnt rice husks, observed that in the interaction between the doses (0, 10, 20, 30, 50 and 100 g ha⁻¹) and the incubation times at 15 days, they presented significant results in relation to the soil pH. Same results found by DONEGÁ et al., 2011; NOLLA et al., 2010; ISLABÃO, 2013, in this study, they observed only small oscillations in pH values over the incubation time, regardless of the doses applied. The results are similar to those observed in bone meal in the survey at 15 days of incubation.

4.2 Effect of Treatments on the pH (H₂O) of the Soil at 30 Days of Experimental Driving

There were significant effects on the interaction between doses and soil improvers at 30 days after the installation of the experiment. For bone meal and oyster flour, the results were adjusted to the quadratic polynomial regression model depending on the doses, while the behavior for limestone was adjusted to the linear regression model (Figure 1).

For bone meal, the considered dose of maximum efficiency was 2.46 t ha⁻¹, resulting in a pH of 4.32. For oyster flour, the maximum efficiency dose was 2.60 t ha⁻¹, resulting in a pH of 4.75. For limestone, the behavior was linear increasing until the last dose applied. (Figure 1)

The use of bone meal did not have a significant effect on the pH elevation depending on the doses applied. Oyster flour, as well as limestone, resulted in higher and more significant effects with the fourth dosage. As a response to the different doses of the corrective agent, the effects were better for oyster flour and limestone, with the exception of the second dose, where the limestone overlapped with the others, bringing about a higher pH. (Figure 1)
The maximum pH values (6.06 and 5.71) were obtained with the dose of 5 t ha\(^{-1}\), of limestone and oyster flour, respectively (Figure 1). The highest pH results obtained with the doses of the corrective agents used in the experiment, estimated by the derivation of the quadratic equation adjusted for pH, are close to the range considered ideal for the development of most crops (5.5 to 6.5), being more satisfactory than those obtained at the 15 days of incubation of the soil improvers.

Moro et al., (2013) studying the availability of nutrients as a function of pH, observed an increase in pH value from 4.5 to 5.5 at 30 days of incubation with dolomitic limestone in the soil. With this, the efficiency of the materials tested as soil acidity correctives is well known. However, the results obtained were lower than those observed by Teixeira et al., (2010) who tested the effects of serpentine rock on the soil chemical attributes observed pH values of 6.5 at 35 days of incubation.

4.3 Effect of Treatments on the pH (H\(_2\)O) of the Soil at 45 days of Experimental Driving

Significant effects were observed for the interaction between the doses and the corrective agents applied (Figure 2). For bone meal, the results were adjusted to the quadratic polynomial regression model, while the results provided by limestone and oyster meal were adjusted to the increasing linear regression model.

For bone meal, the maximum efficiency dose was 3.18 t ha\(^{-1}\), resulting in pH of 4.41. For oyster flour and limestone, due to the linear behavior of the results, it was not possible to determine a dose of maximum efficiency.
The two highest doses of limestone and oyster flour, applied, brought about pH results within the range regarded as ideal for plant development. Limestone, irrespective of the doses applied, was found to have pH values higher than those of oyster meal and bone meal.

The doses of bone meal and oyster flour estimated in this study were higher than those obtained by Lo Monaco et al. (2012) at the 45 days of incubation which, using powder from congo shells (*Brazilian Anomalocardia*) were 2.92 t ha\(^{-1}\) and 3.35 t ha\(^{-1}\), respectively, for the correction of the pH (increase up to 6.5) of soil samples from horizon A and B of a dystrophic Red Latosol. However, they were well below the doses recommended by Ferres et al. (2011), Lasso et al. (2013) and Matos e Matos (2012). Ferres et al. (2011), when assessing the potential of the granite processing residue as a soil acidity corrective, obtaining the acidity neutralization curve, as well as the recommended doses of this residue, found that for pH correction at horizons A and B of a Yellow Red Latosol (LVA), a dose of 30.5 t ha\(^{-1}\) would be required at horizon A and 96.7 t ha\(^{-1}\) at horizon B, for pH correction up to 6.5. Lasso et al. (2013), when evaluating the use of recycled construction and demolition waste as acidity correctives of a dystrophic Yellow Red Latosol, found the need to apply doses higher than 24 t ha\(^{-1}\), concluding that there was no feasibility in this application, due to the cost of freight of the material. Matos e Matos (2012), when evaluating the use of calved sewage sludge as a corrective of acidity in clay soils, concluded that doses of 12.64 to 19.27 t ha\(^{-1}\) would be necessary to reach the pH of 6.5.

5 CONCLUSION

Dolomitic limestone shows better results when compared to the results of oyster flour and bone meal in the incubation periods studied.

Oyster bark flour and bone meal showed effects on pH in periods of greater incubation.
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