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RESEARCH ARTICLE

INFLUENCE OF ROCK PHOSPHATE AND DOLOMITE ON THE QUALITY AND BIODEGRADATION OF A COMPOST BASED ON MAIZE BIOMASS IN WESTERN BURKINA FASO

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ABSTRACT

In the context of climate change and aridity of soils, the manufacture of enriched compost, from corn stalks and with very little animal manure, has often been proposed to obtain a kind of artificial manure. Composting is a fertilization technique that is well suited to the soil. The present study was initiated in order to contribute to a better knowledge of composting with the addition of substrates under the conditions of Burkina Faso. The study of the composting parameters of a mixture of different substrates forming the following four treatments: T1: 600kg of maize stalks + 150kg of manure (Control), T2: 600kg of maize stalks + 150kg of manure + 125kg of BP, T3: 600kg of maize stalks + 150kg of manure + 125kg of dolomite, T4: 600kg of maize stalks + 150kg of manure + 75kg of BP + 75kg of dolomite showed a significant temperature variation in all treatments, with spikes after each turnaround. The initial basic pH decreased for all treatments to approach neutrality at the end of the composting process, especially for the T4 treatment. It should also be noted that there was a decrease in nitrogen concentration, probably due to leaching because of the low initial C/N ratio. This study must continue to determine the maturity of the final product.

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INTRODUCTION

Agriculture is one of the most important economic activities in Burkina Faso (Brunel, 2007). One of the main constraints of agriculture in sub-Saharan Africa is the constant decline in the level of soil fertility, resulting in the continuous decline in crop yields, including maize (Saïdou *et al*., 2012). In cereal-dominant cropping systems, mineral fertilization alone does not maintain soil fertility levels (FAO, 2005). The frequent appearance of mineral deficiency symptoms on crops indicates a strong degradation of soil fertility, leading to a decrease in crop yields. Nutrient depletion caused by continuous cultivation with little or no inputs limits productivity in large tropical and subtropical mountainous regions (PNUE 2004). To combat this soil degradation, farmers use several types of organic manure (household waste, straw, compost, crop residues, manure, litter, poultry droppings and products from the food industry) depending on their availability and spread them directly on the plots. This practice is far from solving the decline in crop yields due to the degradation of soil fertility. Indeed, composting crop residues is perceived as an inexpensive alternative to soil fertilization. However, the use of organic fertilizers has remained low because the farmer cannot have organic amendments such as manure to fertilize his field. In addition, after harvesting, crop residues are either burned or consumed by transhumant animals. The non-recycling of these crop residues has contributed to the decrease in the rate of organic matter, thus affecting soil productivity.

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This very low-input agriculture without recycling crop residues leads to negative nutrient balances and does not allow the long-term maintenance of soil fertility. According to BADO (2002), in Burkina Faso, soil nutrient deficit was estimated at 14 kg N, 2 kg P2O5 and 10 kg K2O per hectare). The use of crop residues could make a decisive contribution to ensuring the maintenance of soil fertility. Mineral fertilisation combined with maize residues recycled into organic fertilisation could help to improve yields and crop balances in N, P, K and S (Koulibaly *et al*., 2010). The production of compost, from maize stalks and with very little animal manure, has often been proposed to producers to improve agricultural production. In view of all these constraints, it is important to find an alternative way of raising and maintaining soil fertility in order to improve crop yields. It is in this context that the present study initiated with the aim of improving the quality of phosphate, magnesium and calcium compost in order to compensate for soil deficits in these elements.

MATERIALS AND METHODS

MATERIAL

The study was conducted in Farako-Bâ, located 10 km from Bobo-Dioulasso on the way to Banfora road. The composting site was chosen to facilitate further operations and subsequent use of the compost. The maize biomass (*Zea mays*) composted for the experiment comes from an experimental plot at the Farako-Bâ research station. The ferment used is cow manure made up of cattle manure. The dolomite used in this study consists of 27% CaO and 19% MgO. It is a carbonate sedimentary rock, light in colour and often massive in appearance, containing at least 50% dolomite. It is used as an amendment in agriculture in the treatment of acidic soils. The rock phosphate or Burkina phosphate used in composting contains 25% P2O5 (of which only 0.03% is soluble in water) and 35% CaO. The addition of rock phosphate increases the solubility of phosphorus and its availability to plants.

MÉTHODS

In this study, the transformation of maize stalks by composting into piles (windrows) was carried out by comparing four (04) treatments defined in Table.

Table. Comparator salaries

Treatments	Substrates used in composting
T1	600kg of maize stalks + 150kg of manure (Control)
T2	600kg of maize stalks + 150kg of manure + 125kg of BP
T3	600kg of maize stalks + 150kg of manure + 125kg of dolomite
T4	600kg of maize stalks + 150 kg of manure + 75kg of BP + 75 kg of dolomite

The cereal stalks were cut into small pieces about ten to fifteen centimeters (10 cm to 15 cm) long using machetes. The method adopted for this test was composting in a rectangular pile covered with plastic film. After the site was cleaned, an area of 2 m long and 1.5 m wide was made using a tape measure. This surface contains four 1.5m high stakes at its corners. A pile has been built. The pile has been a succession of layers. Each layer required operations, the main ones being the following: watering of the surface delimited for this purpose, the construction of a low wall (30 cm) of well-moistened and well-compacted straw, the filling of the hollow formed in the substrate and compaction, an addition of manure, Burkina Phosphate and dolomite, abundant watering and trampling of the layer. These operations were carried out until the end of the weighed substrate. The last layer is covered with a light layer of biomass. After the pile is built, it is covered with a black plastic film to retain moisture and heat. The temperature was measured every day using a thermometer for the first ten days after the windrows were set up and then every three days until the compost was ripe. The turnaround was done every two weeks. The composting time of the maize stalks lasted 100 days with the different substrates used. Watering with water was combined with turning over the piles, in order to obtain a mature compost with a blackish colour. The carbon, nitrogen, phosphorus, potassium and water pH contents were determined by the INERA laboratory in Farako-Bâ.

RESULTS ET DISCUSSION

RESULTS

Water consumption during composting: The quantities of water used for watering during composting varied from 2374 to 3139 litres (Figure 1). The T3 treatment consumed the highest amount of water for composting during the entire process, followed by the T1 treatment with 2794 litres. On the other hand, the composting of the T4 treatment did not require a large quantity of water (2374 litres). The quantities of water used, which were 4066 litres at the beginning of the composting process, were considerably reduced at the end of the operation with the decomposition and maturity of the plant debris, which can be seen in a reduction in the height of the composting piles.

Temperature evolution: The study of the temperature evolution during the composting process showed a variation depending on the substrates used. On Day 1, there was no significant variation in temperature between treatments. On the 4th day of composting, a temperature rise of 40°C to about 72°C is observed at the level of each treatment. On the 7th day, the temperature drops slightly for the treatments. On the 8th day, there was a variation in temperature between treatments, with a considerable drop in the level of T2. On the other hand, the temperature increases significantly from 68°C to 72°C. On the 9th day, there was a considerable decrease in all treatments. Thereafter, there is a slight variation between treatments with a decrease in T2 and a slight increase in T3 from about 52°C to 59°C. This variation continues until the end of the process. During the composting period, several temperature peaks were observed indicating high variability depending on the treatment. On all the treatments, a temperature peak was noted after each heap turning operation. At the end of composting, temperatures stabilize at around 37°C, which shows low microbial activity which denotes the maturity of the composts. The maturation phase can be considered to begin on the 73rd day of composting.

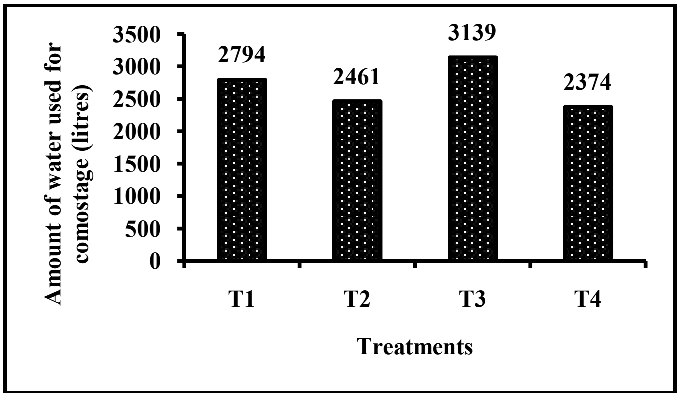

Figure 1. Total water consumption during composting by treatment

Evolution of pH: The evolution of the pH during composting initially indicates that the pH of all treatments is greater than 7 (Figure 2). The water pH of these treatments tends to decrease gradually until the end of composting. In general, the variations in the water pH of the different treatments were small during the decomposition process. It is noted that from the 60th day of the reversal (R5), the pH of water, which is close to neutral, stabilizes due to the cessation of the activity of the microorganisms responsible for its variation.

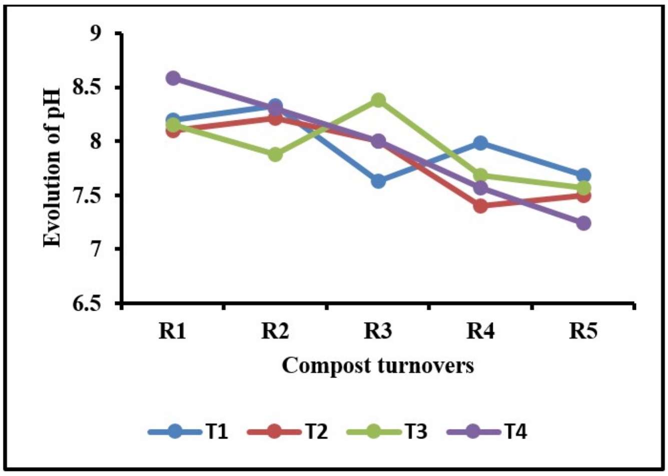

Figure 2. Evolution of water pH during composting

Evolution of the C/N ratio: The evolution of the C/N ratio during the composting process for each turning is shown in Figure 3. At the beginning of composting, the ratio value is very high and is between 35 and 45. The shape of the curves reflects a decrease in the C/N ratio during composting on all treatments. The values of the C/N ratio at the end of composting are between 27 and 32.

***Potassium*:** The evolution of potassium during the composting process shows a variation in its concentration over time depending on the substrates used (Figure 5). At the beginning of composting, K contents were above 1% and dropped sharply after about two weeks.

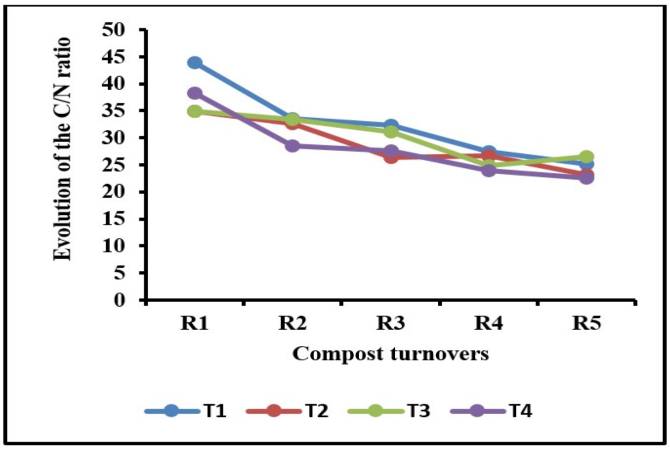

Figure 3. Evolution of the C/N ratio during composting

With the use of dolomite and manure as ferments in the composting of maize stalks (T3), higher K levels have been observed, which decrease throughout the composting time, although a slight increase is noticeable on the 40th day. At the end of composting, potassium levels are between 1% and 2% regardless of the substrates used.

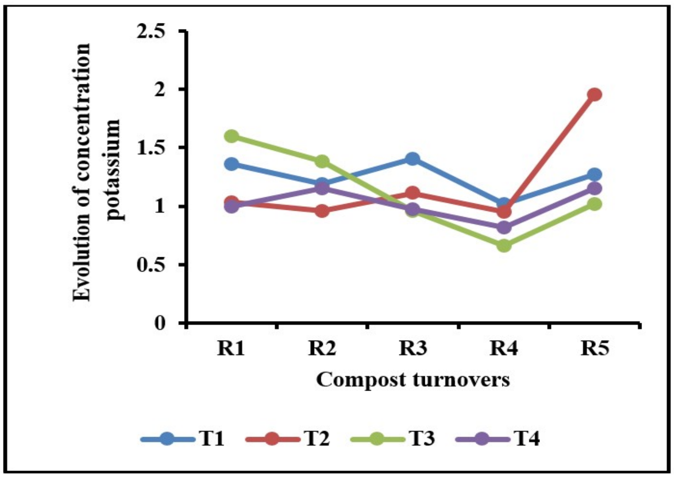

Figure 4. Evolution of the Potassium concentration during the composting process

Magnesium: Magnesium levels that were high at the beginning of composting appear to remain constant until the compost matures (Figure 5). With the exception of the treatment with dolomite alone (T3), the other treatments show no significant variation in K contents, which are between 0.5 and 1 at the end of composting.

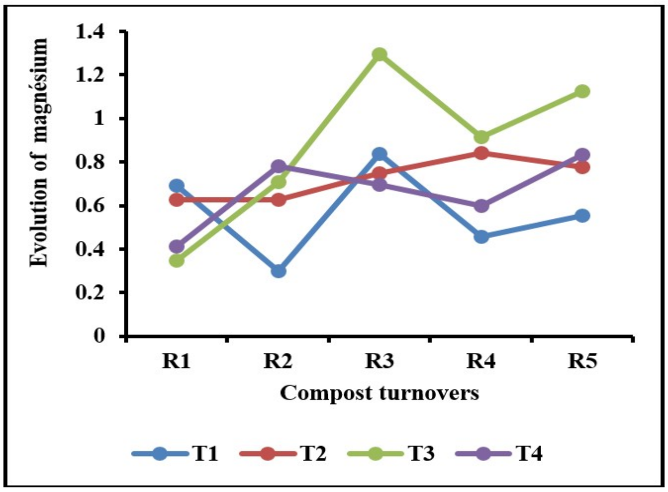

Figure 5. Evolution of the Magnesium concentration during the composting process

Calcium: The evolution of calcium content during the composting process reveals that the use of cow dung and rock phosphate alone (T2), cow dung and dolomite alone (T3) or cow dung combined with both substrates (T4) are significantly higher than those of the T1 treatment (Figure 6). This difference is maintained until the end of composting with a slight decrease in Ca contents on the T2 and T3 treatments.

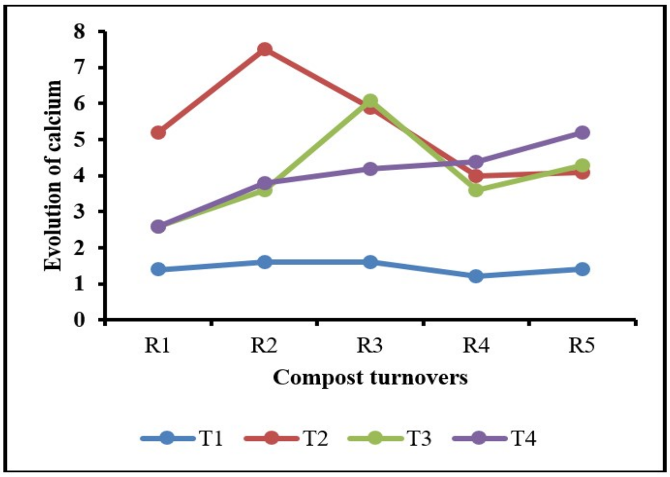

Figure 6. Evolution of the calcium concentration during the composting process

DISCUSSION

Composting with maize stalks, carried out over a period of about 100 days, indicates a reduction in composting time compared to the composting usually practiced by farmers, which could exceed 300 days. In addition, this reduction in composting time has also reduced the quantities of water used, which are comparable to those obtained by Taoré (2008). The results showed that the temperature rose rapidly in the first few days after planting before dropping towards the end of the composting process. These high temperatures could lead to pathogen reduction and weed seed removal (Tognetti *et al*., 2007). High temperatures characterize aerobic composting processes and are indicators of significant microbial activity (Compaoré and Nanéma, 2010). As for the peaks observed following overturning, ITAB (2001) showed that they are due to material that remains at the edge and only increases in temperature after turning, when it is introduced into the window. This drop in temperature can be explained by a slowdown in the activity of microorganisms due to the depletion of easily degradable organic matter (Soudi, 2001). Also, the drop in temperature towards the end of composting reflects the maturation phase characterized by low microbial activity. The pH value at the beginning of the decomposition process is given by the composition of the starting materials. The pH value that evolves towards neutrality over time is an indicator of a smooth process. Variations in the pH of different treatments during the decomposition process could be explained by the accumulation of certain nutrients in plant biomass and litter (Yelemou *et al.,* 2020). Many authors reveal in their work that acidic pH is characteristic of immature composts, while mature composts have pH close to neutral or higher (Francou 2003, and Albrecht 2007).

Losses of organic matter and carbon come from the degradation of carbon into carbon dioxide by microorganisms. They are between 50 and 60% of the initial carbon. Carbon losses increase while an increase in nitrogen occurs, thus justifying the decrease in the C/N ratio of composts. The C/N ratio characterizes the dynamics of organic matter transformation. According to Soltner (2003), C/N ratios make it possible to monitor the evolution of organic matter, to assess the richness of humus in nitrogen and to make compost favourable to mineralization. The C/N ratio dropped significantly. This could be explained by ammonia lost through volatilization and the remaining nitrogen is used by microorganisms (Bazongo *et al.*

2015). Nitrogen losses often observed during composting could occur through volatilization. With three (03) reversals, they are usually between 50 and 60% when the reversals are frequent. These results are comparable to those obtained by Compaoré and Nanéma, (2010) on compost from crop residues, household waste and improved park manure. The addition of natural phosphates to composting accelerates the decomposition of composted substrates and increases the quantities of soluble phosphorus. According to Pouya (2008), the combination of rock phosphate with organic manure improves the efficiency of mineral fertilizers. For a better efficiency of Burkina phosphorus with a view to a better availability of phosphorus, the addition of Burkina phosphorus to an organic source is recommended as shown by Lompo (2005). Indeed, the addition of rock phosphate further increases the levels of Pt and Pass, due to the action of organic anions (citrates and oxalates) from the decomposition of organic matter (Compaoré *et al*., 2000). The contribution of dolomite to composting consequently contributes to the improvement of the calcium and magnesium content of the composts produced. In addition, the loss of organic matter depends not only on the nature of the materials being composted but also on the nature of the different substrates BP, dolomite and manure (Lompo *et al*., 2009). In addition, dolomite is rich in calcium and magnesium, which could cause increased calcium and magnesium levels. Dolomite keeps the C/N ratio at an acceptable value. In addition, the loss of organic matter depends not only on the nature of the materials being composted but also on the nature of the different substrates BP, dolomite and manure. The contributions of rock phosphate to composting resulted in an increase in the phosphorus content of the compost. This is what justifies the low phosphorus content in treatments without the addition of phosphate rock. Phosphate rock inputs are also important in improving calcium content. Mass losses are usually between 30 and 40% from the starting mass, but can sometimes be as high as 60%. The results showed that compared to the initial contents of the materials to be composted, the losses of organic matter vary between 62 and 72% after 70 days of composting. These results are explained by the microbial decomposition process of organic matter that occurred during composting. The same observation was made by Lompo *et al*., (2009). Rock phosphate appears to increase the loss of organic matter. While improved aeration may be enough to increase microbial activities with manure as a source of organic matter. Thus, the application of manure to composting has not only accelerated the decomposition process of maize stalks, but also improved the quality of the composts. This last element is justified by the composition of the compost of the control treatment with the manure alone.

CONCLUSION

The present study on the valorization of corn stalks aims to improve composting techniques using manure combined with dolomite and rock phosphate. The study evaluated various parameters based on maize stalk composting techniques. The results of the study highlighted positive effects observed on the speed of decomposition of the stems and on the quality of the composts obtained. The study confirms the effectiveness of dolomite and rock phosphate in composting maize stalks. A reduction in the duration of the composting process and in the quantities of water was observed, as well as an improvement in the chemical characteristics of the composts. The combination of substrates, dolomite and natural phosphates with manure has been shown to be more interesting because of the effects of these substrates on the decomposition process and on the quality of the compost obtained. Indeed, dolomite and Burkina phosphate create favourable conditions for the development of microorganisms, which results in an acceleration of the degradation of composting materials. These substrates improved calcium and total phosphorus levels. In addition, the addition of dolomite reduced the high C/N ratio in compost produced solely from corn stalks. In general, the results obtained show the interest of the use of organic matter decomposition activators in composting such as manure, dolomite and phosphate substrates. Given the acidifying effect of mineral fertilizers through their almost exclusive use, the recycling of maize stalks enriched with substrates (BP, dolomite) into compost could be a promising alternative to improving yields and crop balances. With a view to sustainable management of soil fertility in Burkina Faso, it seems important to us to disseminate and promote these compost enrichment techniques for a better recovery of crop residues, particularly maize stalks. A real involvement of producers in this initiative could contribute significantly to the increase in agricultural yields, the sustainability of soil management and cropping systems.

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