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Recovery of Organic Waste with Other Biological Components for the Production of Organic Fertilizer: Improved Biochar

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Abstract

The study was carried out in Baham district in the West Cameroon region, as part of the recovery of organic waste with other biological components for the manufacture of an organic fertilizer (improved biochar). Through observations and a survey questionnairy submitted to 100 farmers, it appears that the majority use synthetic chemical fertilizers. Farmers using chemical fertilizers find them dangerous to their health. In addition, 58.57% of these farmers said they felt unwell after spreading these fertilizers. However, 64.28% of these farmers do not acquire PPE for reasons of financial means on the one hand and ignorance on the other hand. 54.28% of respondents using only chemical fertilizers noted declining agricultural production. The surveys also reveal that biochar (of plant origin) as a solution proposed by CIPCRE is used by a minority of farmers (21%) in the said locality on the one hand and on the other hand has limits in terms of intake nutrients for crops; this was confirmed by analyzes of the physico-chemical parameters.

Keywords

Organic Waste, Biochar, Improved Biochar, Sustainable Agriculture

1. Introduction

Biochar (pyrolysed organic matter) inputs to soils have been proposed as a technique to stabilize soil carbon, manage organic wastes, produce energy and improve soil fertility. The present work shows the state of art, the main problems and gaps in knowledge regarding the problem that occurred with biochar in soil fertility and carbon sequestration (Abiven, 2011). Baham has on the whole red ferralitic and sometimes lateritic soil types. This soil is fairly low in plant nutrients and this result is shown true to the low agricultural yields (PNDP, 2014). Biochar has then been proposed as a new technic in the scientist community as a type of agriculture management used to improve the storage of carbon in the soils. This technique raises many hopes, especially among policymakers, about the possibility of mitigating climate change through agricultural practices. If the first results seem positive and sometimes surprising (Abiven, 2011), faced with this, the main agricultural populations have resorted to the use of chemical inputs. The use of these is done in an uncontrolled and inappropriate way, thus exposing farmers and consumers to numerous risks of contamination and environmental pollution (IRAM, 2017). In order to resolve this problem, CIPCRE offered biochar (of vegetable origin) to farmers in the Baham groupment. However, according to the characteristics of the majority of Baham area soils, this biochar has limits. Baham has ferralitic red soil overall, it is quite poor and induces low agricultural yields, hence the need to resort to the fertilization system. There are lowland areas with fairly fertile soils through the humus deposits following river erosion (Alaplante et al., 1951). This study aims to contribute to the protection of the environment through improved biochar (biochar combined with *Tithonia diversifolia*, chicken droppings and Bokashi) for sustainable agriculture in Baham. Specifically, it will be a question for us to have knowledge of the farmers' perception of the use of fertilizers, to manufacture and characterize the improved biochar and to assess the economic cost of this fertilizer.

2. Material and Methods

Several materials were used in this study such as: biomass waste, which is corn cobs, waste from wheat (wheat bran), chicken droppings, water, biological components which are *Tithonia diversifolia*, commonly known as jealousy flowers, and the effective microorganisms were purchased from the market (EM).

A survey questionnaire on the themes relating to the use of fertilizers was administered to a reasoned choice sample of 100 farmers. The surveys were carried out in five main villages (Kamkho, Poumze, Baho, Mendjo and Chenye) in the highlands department of the West Cameroon region. After these inquiries, we obtained different perceptions. The second stage consisted in the production of biochar. Through a device (biochar stove) powered by wood shavings (which serve as fuel), pyrolysis was used to carbonize the corn cobs. At 50 kg of biochar were combined 15 kg of *Tithonia diversifolia*, 15 kg of droppings hens and 4 kg of bokashi (wheat waste + 40 mL of microorganisms diluted in 1 L of water, the whole fermented for 14 days). All these elements were mixed and led to a homogeneous mixture. 225 mL of effective microorganisms diluted in 10 L of water was added to the homogeneous mixture and was homogenized again; thus leading to improved non-mature biochar. The latter is conditioned in plastic-lined bags for 21 days anaerobically to become mature improved biochar.

The two samples (biochar and improved biochar) were prepared in order to check whether some physicochemical properties have been improved. The samples were taken and brought to the Soil Analysis and Environmental Chemistry Research Unit (URASCE) of the Faculty of Agronomy and Agricultural Sciences (FASA) at the University of Dschang. The analyzes carried out mainly included, the apparent density, the porosity, the specific surface, the pH in aqueous media, the organic carbon content, the total nitrogen content, the content of exchangeable bases (Ca, Mg, K and Na), the cation exchange capacity and the total phosphorus content. These physico-chemical parameters contained in the two samples were analyzed according to the methods in force at URASCE, recommended by Pauwels et al. (1992) and complying with ISO, AFNOR NF and EN standards. For the evaluation of the economic cost of the improved biochar, the cost calculation method was used.

Statistical Analysis

Analysis of data from field surveys was done with Excel.

3. Results and Discussion

Most of the land work (63%) is carried out by people aged 50 and over. Surveys also show that 62% of farmers have primary education. Farmers who have made extensive use of synthetic chemical fertilizers, it appears that 54.28% say that agricultural production is declining. This result joins the study of Cheng et al. (2006) who showed that uncontrolled and inappropriate use of chemical fertilizers (nitrogen, phosphorus and potassium) would lead to the depletion and sustainability of soil fertility; and consequently the plants would remain without supply of nutritive elements, this would lead to poor agricultural production. 41.61% of the farmers using biochar said that it is not very accessible and the products resulting from its use have a small volume. In addition, 33.33% said that biochar has a low yield. These results are similar to the studies by Lévesque (2017), which showed that biochars of plant biomasses have a very low nitrogen content; therefore their C/N ratios are also very high. Ndoum Ng'owona (2000), show that these reports are not favorable for agriculture because there is a temporary immobilization of nitrogen in the soil by microorganisms this causes nitrogen hunger for crops due to the slow decomposition of the organic matter these results were also found by Wardle et al. (2008) who shows the greater decomposition of boreal forest litter in the presence of biochar at about 20%. This improved biochar could then enhance the Baham area soil fertility. The surveys also revealed that 61.42% and 30% of farmers using chemical fertilizers find them very expensive, respectively; similar to studies by INS (2009) which show that rural activities are mainly practiced by the poor; they finance themselves (97.8%) for most of their agricultural activities. The diagrams in **Figure 1** and **Figure 2** show the distribution of the farmers surveyed by gender and age group.

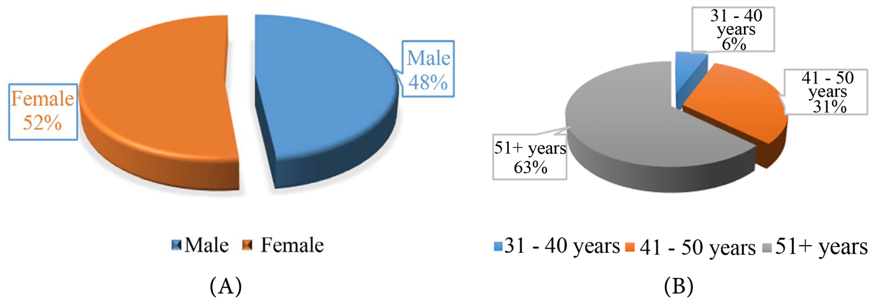

Figure 1. Distribution of peasants surveyed by gender and age. (A) Distribution of peasants surveyed by gender; (B) Distribution of peasants surveyed by age.

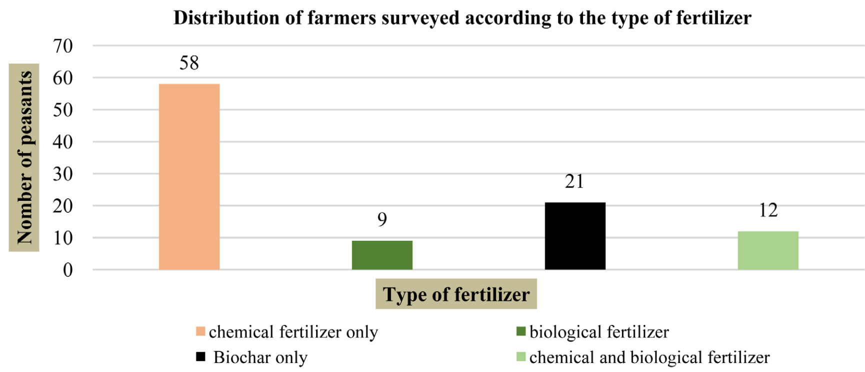

Figure 2. Distribution of farmers surveyed according to the type of fertilizer used (A): *Tithonia diversifolia* Foliage; (B): Cut out of *Tithonia diversifolia* Leaves; (C): Corn cobs; (D): One (1) liter bottle of effective microorganisms (EM); (E): Waste from wheat; (F): Chicken droppings.

The different ingredients presented in Photo 1 above are organic and biodegradable ingredients used to produce the improved biochar. these ingredients are among others, the green leaves of *Tithonia diversifolia*, corn cobs, some microorganisms that will allow the biological degradation of organic matter, wheat waste as well as chicken droppings that have been crushed and added to the biochar in order to improve its quality for better agricultural yield; the use of those elements were to show the advantage for using biological and natural waste to improve agricultural yield and protect the environment.

From the analysis of the physicochemical parameters of the two samples, the results show the pH is 7.4 for the reference biochar against 8.7 for the improved biochar. This pH is favorable for mostly ferralitic and sometimes lateritic soils for the study site. This goes in the same way as the studies by Ndoum Ng'owona (2000), which shows that pH directly influences the microbial life of the soil, the assimilation of major elements and trace elements. This same author also shows that a too low, lower pH (4.5 - 5) contributes to considerably slowing down the mineralization of organic matter and decreasing the quantities of nitrogen available. On the other hand, the values at high pH (6.5 - 8) accelerate the mineralization and the release of nitrogen. For the contents of exchangeable cations, we obtained the values of two samples. Those of normal biochar are as follows:

1480 mg/kg for calcium, 583.2 mg/kg for magnesium, 96.6 mg/kg for potassium and 22.3 mg/kg for sodium. On the other hand, those of improved biochar are: 4640 mg/kg for calcium, 826.2 mg/kg for magnesium, 588.2 mg/kg for potassium, and 82.2 mg/kg for sodium. We obtained analyzes of the cation exchange capacity (CEC) values of each sample. Normal biochar gave a value of 51.20 Cmol/kg compared to 67.68 Cmol/kg for improved biochar. This is in line with the studies of Lévesque (2017), which showed that a high CEC can promote soil aggregation. The results are presented in **Figure 3** below.

Regarding the specific surface, we obtained a value of 59.68 m^2/g for normal biochar, against 211.85 m^2/g for improved biochar. Studies by Lévesque (2017) show that biochar with a specific surface greater than 100 m^2/g would be beneficial in improving soil fertility and would allow carbon sequestration. In the same vein, studies by Chan and Xu (2009) have shown that a large specific surface

Photo 1. Board of the different study materials used. (A) *Tithonia diversifolia* foliage; (B) Cut out of *Tithonia diversifolia* leaves; (C) Corn cobs; (D) One (1) liter bottle of effective microorganisms (EM); (E) Waste from wheat; (F) Chicken droppings.

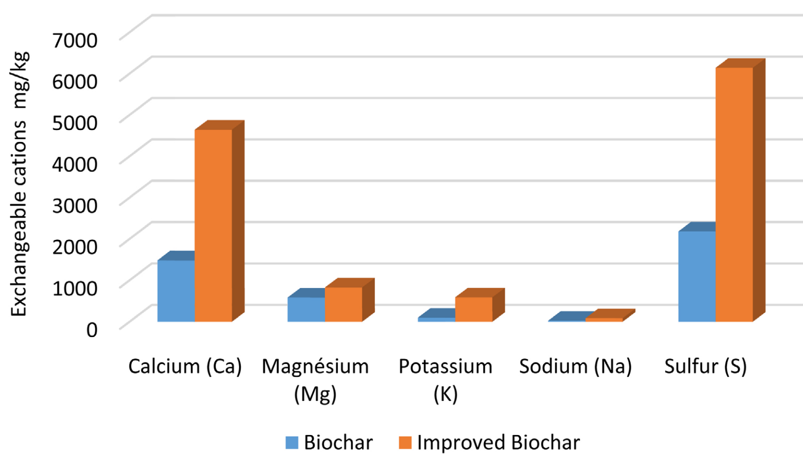

Figure 3. Contents of exchangeable cations of biochar and improved biochar.

area provides shelter for microorganisms and a place to store nutrients from the soil. Regarding the apparent density, we had 0.67 g/cm^3 for normal biochar and 0.42 g/cm^3 for improved biochar. Downie et al. (2009) showed that the addition of low-density biochar to the soil allows, on the one hand, to reduce the mass density of the soil in order to allow the roots of plants to penetrate into the soil for their better development; and in the other hand, to favor high retention of humidity. For porosity, biochar gave us a value of 74.71% against 84.15% for improved biochar. For organic carbon contents, we obtained 42.75% for normal biochar against 45.19% for improved biochar. This presents similarities with the works of Lévesque (2017) which recommend biochar as an amendment, with a total Carbon content greater than 15%. With regard to the major nutrient contents, those of biochar are as follows: 0.62 g/kg for total nitrogen, 139.3 mg/kg for total phosphorus and 96.6 mg/kg for potassium. On the other hand, those of the improved biochar are as follows: 3.77 g/kg for total nitrogen, 345.0 mg/kg for total phosphorus and 588.2 mg/kg for potassium. Regarding the C/N ratio, we obtained a value of 64 for biochar against 12 for improved biochar. The studies of Beernaert and Bitondo (1992) allow us to appreciate the two samples. Biochar can be described as very poor (C/N = 64 > 20). On the other hand, the improved biochar is of good quality (10 < 12 < 14). Ndoum Ng'owona (2000) studies have shown that C/N values below 20 indicate faster decomposition of organic matter and availability of nitrogen for crops. When used too much, C/N values greater than 60 indicate that the decomposition of organic matter is slower.

4. Conclusion

The improved biochar is presented as a favorable and recommended solution for sustainable agriculture for the farmers in the group; this by its physicochemical properties such as: a basic pH (8.7), a fairly high CEC (67.68 C_{mol}/kg), a large specific surface (211.85 m^2/g), a large porosity (84.34%), a low apparent density (0.42 g/cm^3), appreciable contents in exchangeable cations and a large composition in major nutrients (3.77 g/kg for total nitrogen, 345.0 mg/kg for total phosphorus and 588.2 mg/kg for potassium). The objective here was to recover organic waste from the study site in order to produce improved biochar to contribute to the practice of sustainable agriculture in the locality of Baham. Given the quality of the lateritic and ferralitic acid soils of the study area, it was imperative by adding all the major nutrients like nitrogen to biochar to bring its pH down to 8. Compared to the high cost of chemical fertilizers, improved biochar is natural.

Socially, the improved biochar will preserve the health of peasants who were once at great risk during and after handling chemical fertilizers, it will also enhance food security because the products derived from the use of fertilizers organic are more reassuring and reassuring for human health. In addition, these products can be stored easily and for longer or shorter periods depending on the type of product (vegetable or food products from organic fertilizers are less rotten compared to those from chemical fertilizers). Economically, this study allows us to capitalize on the management of organic waste; in particular the development of *Tithonia diversifolia* which was not yet valued by farmers. It constitutes a real potential acquired for the peasants. Compared to chemical fertilizers, improved biochar is obtained at a very affordable cost. From an environmental standpoint, the improved biochar constitutes a real solution for the restoration of degraded and impoverished soils by the excessive and inappropriate use of chemical fertilizers in the locality of Baham. By virtue of its characteristics, the improved biochar will be able to reduce the acidity of Bahamian soils, which are for the most part acidic, and will thus promote the good development of microbial life, which in turn will promote the degradation of organic matter by making it available to cultures. It will therefore help maintain the organic status of the soil, which is a guarantee of the sustainability and productivity of production systems. In addition, the improved biochar will be a real sink for carbon storage and therefore will help reduce greenhouse gas emissions.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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