Tropentag, September 16-18, 2015, Berlin, Germany

"Management of land use systems for enhanced food security: conflicts, controversies and resolutions"

Characterisation of Biochar from Maize Residues Produced in Lab-Scale Batch Reactor without Using Carrier Gas

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Abstract

Maize residue is one of the most abundant crop residues worldwide, but it is still underutilised. Therefore, it can be converted into biochar for simultaneously addressing agricultural, environmental, and energy issues. In this study, the effects of different operating temperatures (300, 450, 600°C), heating rates (5, 10, 15°C/min), and residence times (30, 60, 90 min) on four response variables including volatile matter content, ash content, pH, and electrical conductivity (EC) of biochar were evaluated. Biochar was produced from four maize biomass fractions (cobs, stalks, husks, and leaves). The experiments were arranged according to the Box-Behnken design using the response surface methodology. The optimal pyrolysis conditions to obtain the best quality biochar in terms of volatile matter content, ash content, pH and EC for soil amendment were identified. The biochar was further characterised by using the elemental analyses and scanning electron microscopy (SEM). ANOVA results indicated that the operating temperature had the most significant influence on the four responses of the biochar. Ash content, pH, and EC of all biochars were significantly increased with increasing operating temperature; while the volatile matter content drastically decreased. The residence time and heating rate showed less effect on these four responses. It was found that the husk and leaf biochar were more desirable for soil amendment with the optimal conditions of 600°C, 5°C/min, 90 min and 600°C, 15°C/min, 79 min, respectively. The leaf biochar contained the highest C content and increased with rising operating temperature (76.3 to 89.2 wt. %). Nitrogen content was found to be higher in leaf biochar (1.60 to 1.98 wt. %). For the elemental composition, the leaf biochar presented the highest Ca and P contents; while the highest K and Mg contents were found in the stalk biochar. Cob biochar was characterised with the lowest contents of Ca, K, Mg, and P. The SEM images verified the existence of porous structures in the biochar. Based on these findings, it could be recommended that maize husk and leaf were suitable to be converted into biochar for soil amendment at 600°C.

Keywords: Biochar, lab-scale batch reactor, maize residues, response surface methodology, scanning electron microscope

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