Effects of pyrolysis temperature and residence time on rice straw-derived biochar for soil application

ABSTRACT

Aims: A study was conducted to assess the rice straw-derived (Rsd) biochar in relation to temperature and residence time. Study Design: Rsd biochar was pyrolyzed at different temperatures (300ºC, 400ºC, 500ºC and 600ºC) in a combination of different residence times (45 min, 60 min and 120 min) namely 300-45, 300-60, 300-120, 400-45, 400-60, 400-120, 500-45, 500-60, 500-120, 600-45, 600-60, and 600-120, respectively. Place and Duration of Study: The study was conducted in the laboratory of Institute of Tropical Agriculture and Food Security, Universiti Putra Malaysia, Malaysia, between July to September 2014. Methodology: A suite of analytical procedures was performed to evaluate the Rsd biochar characteristics. Results: The results showed that the biochar yield decreased when the pyrolysis temperature increased. The physicochemical and structural characteristics of the biochar were significantly influenced by pyrolysis temperature. Scanning Electron Microscope (SEM) images indicate significant macro-porosity (size between 1-10 µm) and were clearly visible across the surface of 300ºC (60 min) compared to other temperature values and residence times. Increase in temperature gave rise to a nodule-like visible indicator of silicate presence on the surface. Macro-porosity presence in biochar is an indicator that it can adsorb and retain water and nutrient for plant-root hair uptake. Meanwhile, Brunauer-Emmett-Teller (BET)-N_2 surface area ranged from 2.36-6.26 m^2 g^{-1}, for 300 to 500ºC, respectively. Surface area controls materials' ability to adsorb chemical compounds, as larger surface area means more porous structures within biochar. H/C and O/C ratio decreased as the temperature increased, indicating condensed carbon in biochar. The pH increased with the increment of pyrolysis temperature. Conclusion: Rsd biochar at 300-60 and 400-60 showed good potential characteristic with macro-porosity and surface area increases, and should thus be suitable as a soil amendment for agricultural activity.

Keyword: Black C; Charring; Pyrolysis temperature; Residence time; Sustainable waste recycling