SPECIFIC CHARACTERISTICS OF BIOCHAR FROM SLOW PYROLYSIS AND THE IMPACT ON SOYBEAN YIELD OF WOOD CHAR FROM GASIFICATION

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（緩速熱分解による炭化物の特性とガス化による炭化物のダイズ収量に及ぼす影響）

区　　分　：甲

論　文　内　容　の　要　旨

Studies on biochar have increased recently; however, its diversity needs further in depth research to gain a greater understanding about its potential benefits. The diversity in biochar research comes from various feedstocks, production processes, and approach methods. The main aim in this study was to identify the potential benefits of biochar for agricultural utilization. The study approached the characteristics of both slow pyrolysis biochar (a product of the slow pyrolysis) and gasification biochar (a byproduct of gasification). In addition, this study explored the functions of those biochars on agricultural soils (physicochemical properties) and soybean yield.
The analytical study on slow pyrolysis biochars was conducted with different feedstocks: rice husk, wood, and bamboo, and pyrolysis conditions at the following temperatures: 400°C, 600°C, 800°C and resident times: 1 hour and 2 hours. The purpose for conducting the experiments in these various conditions was to find the difference in their characteristics. The results showed rice husk biochar had higher pH & EC, larger ash and silicon contents but less carbon content compared with the others. While wood biochar had high carbon content but contained fewer other elements than the others. Bamboo biochar had potential in enhancing the potassium content and water-holding capacity of soil. Bamboo biochar produced at 600 °C proved to be the best temperature in increasing soil potassium (K) and water-holding capacity. The 600-1 (600 °C with one hour resident time) biochar had the highest potassium content (4.87%), with the second largest water holding capacity of 3.73 g g-1, whilst the 600-2 one had the second-highest potassium content (4.13%), and the largest water holding capacity (4.21 g g-1) and cation exchange capacity. The release of K in 600 °C biochar was larger and slower than that of the 400 °C and 800 °C ones, respectively. The results also indicated that the physicochemical characteristics of bamboo biochar, such as yield, pH, surface area, water holding capacity, and K content were significantly impacted by temperature, retention time, or a combination of these parameters. Outcomes from this study is a valuable reference for bamboo biochar production targeting agricultural soil amendment, particularly when it is directed at increasing soil K and water holding capacity.
Another biochar type, a byproduct of gasification is expected to increase in the future owing to need for bioenergy to support sustainable development. The author investigated the suitability of two gasification biochars, wood (W) and rice husk (R) biochars, for agricultural use, and specifically, compared their potential in enhancing agronomic efficiency of nitrogen fertilizer (N-AE) for soybeans yield in two consecutive cropping. Four treatments were used: F0, without nitrogen fertilizer; F, using nitrogen fertilizer, W-F, using W & nitrogen fertilizer; and R-F, using R & nitrogen fertilizer. A pot experiment was conducted from July to October in 2019 – 2020. In the first cropping, the application of gasification biochars increased N-AE; however, the impact of W and R was not significantly different. The increase in N-AE was attributed to soil properties change after the biochar application. W application shows the largest impacts on reducing bulk density (BD) and water-holding capacity (WHC). R amendment significantly increased soil exchangeable potassium (K). Moreover, these two biochars had higher pH and cation exchange capacity (CEC) than soil. The application of W and R increased the available phosphorus (P) but

reduced the concentration of ammonium nitrogen. In two consecutive cropping, the increase in N-AE was maintained in W and R, especially for W. This corresponded to the potential of W in maintaining higher soil pH and larger quantities of available P in soil. However, R did not indicate any significant differences in changing soil physicochemical properties after two consecutive cropping.

Soybeans can be cultivated without nitrogen fertilizer due to their ability for nitrogen fixation. To meet the requirement of soybeans with nitrogen in the initial growth stages, compost is used. Another study was conducted to understand the consecutive impacts of wood gasification biochar combined with compost on soybeans. The soil was mixed with 50 g/pot compost, a 2% (w/w) commercial wood gasification, and 0.5 g/pot urea nitrogen fertilizer (NF) were used in an experiment with four treatments: W-NF, with W and NF; Wo-NF, without W and with urea fertilizer (Japanese practice); W-NFo, with W and without urea; and Wo-NFo, without both W and urea fertilizer. Soybeans were grown in a pipe-house from July to October in 2019 – 2020 at Ito Campus of Kyushu University. The three major effects of wood gasification biochar on clayey soil and soybeans based on compost were: (1) biochar application significantly increased soybean nodules (number and weight) and root weight in two consecutive crops; (2) Without NF, the content of $NH4^{+}$ in the biochar treatment (W-NFo) significantly increased compared with that when biochar was not used; and (3) Without NF, W combined with compost can maintain the yield of soybeans equivalent to ones of nitrogen treatments. Those increases resulted from the changes in soil properties, including BD reduction, WHC, pH enhancement and maintaining $NH4^{+}$ content. Moreover, the nutrients uptake in soybean seeds did not significantly differ in all treatments.