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Enhancing soil fertility and polyphenol composition in highland arabica coffee through agricultural biochar application

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Abstract

This study investigated the influence of biochar derived from highland agricultural residues on soil physicochemical properties and the polyphenolic profile of *Coffea arabica* beans during the harvest season in northern Thailand. The experiment was conducted at the Nong Hoi Highland Agricultural Research Station in Chiang Mai Province, a region renowned for Arabica coffee cultivation. Biochar was incorporated into the soil at a rate of 2.5 % (w/w). Five coffee plants received the biochar treatment, while five untreated plants served as controls. Post-application assessments revealed a marked improvement in soil chemistry, with soil pH increasing to 5.99. Additionally, extractable potassium and magnesium concentrations significantly increased to 106.20 ± 3 mg kg^{-1} and 29.48 ± 0.15 mg kg^{-1}, respectively, indicating enhanced nutrient availability. In terms of bean quality, biochar application resulted in a significant increase in catechin content (22.16 ± 0.40 mg 100g ^{1}) compared to the control (19.07 ± 0.75 mg $100g^{-1}$; p 0.05). This elevation in catechin levels may be attributed to improved micronutrient status and enhanced rhizosphere microbial activity, notably from siderophore-producing and iron-solubilising bacteria, which are known to promote flavonoid biosynthesis. Although not statistically significant, slight increases were also observed in the concentrations of gallic acid (0.36 mg 100g ^{1}), caffeic acid (2.03 mg 100g ^{1}), naringin (0.73 mg 100g ^{1}), rosmarinic acid (0.11 mg 100g ^{1}), o-coumaric acid (0.09 mg 100g ^{1}), and quercetin (0.10 mg 100g ^{1}) in the biochar treatment when compared to the control. In conclusion, the application of biochar not only enhanced soil fertility but also contributed to the improvement of health-promoting compounds in Arabica coffee beans. These findings support the use of biochar as a sustainable soil amendment for enhancing both soil health and bean quality in highland coffee production systems.

Keywords: Arabica coffee, Biochar, Highland , Polyphenolic compounds

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