Characterization of Coffee Pulp Biochar and Its Impact on Soil Properties and Microbial Populations

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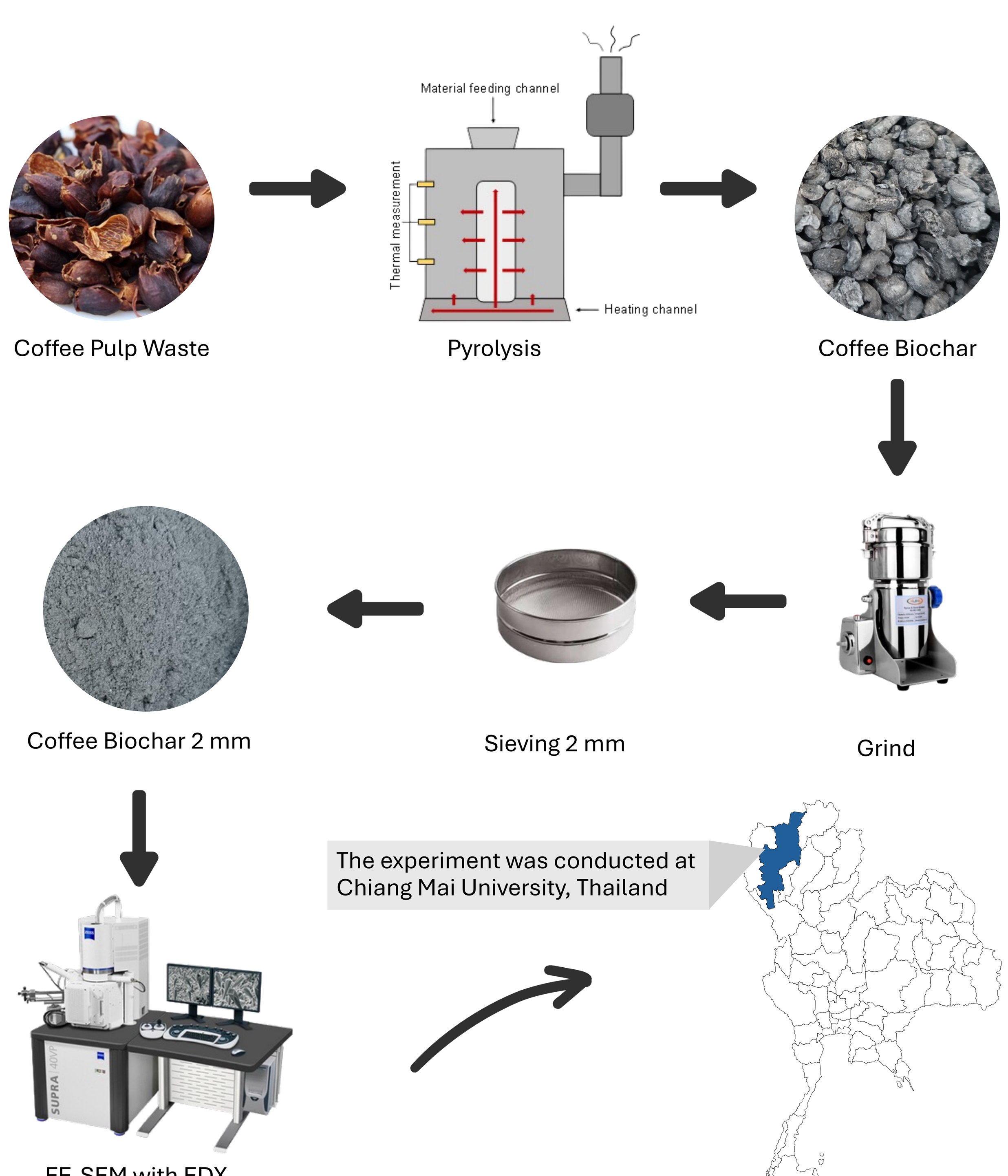
Materials and Methods

- The experimental design employed was a Completely Randomized Design (CRD), comprising 5 treatments and 10 replications. These methods involved mixing coffee pulp-derived biochar into soil at rates of 0, 2.5, 3.75, 5, and 7.5% of soil weight.
- The soil properties and microbial populations will be analyzed using one-way ANOVA. Significant differences will be determined by the least significant difference (LSD) test at a 95% confidence level. Data visualization and statistical presentation were performed with SigmaPlot 15.0.



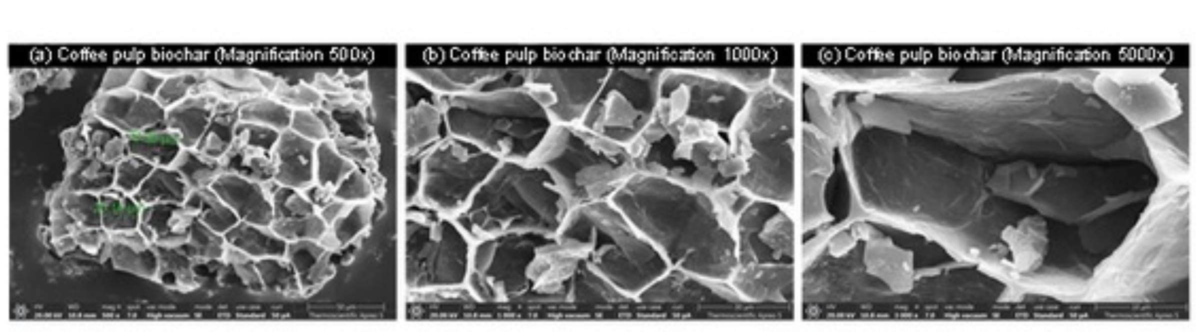
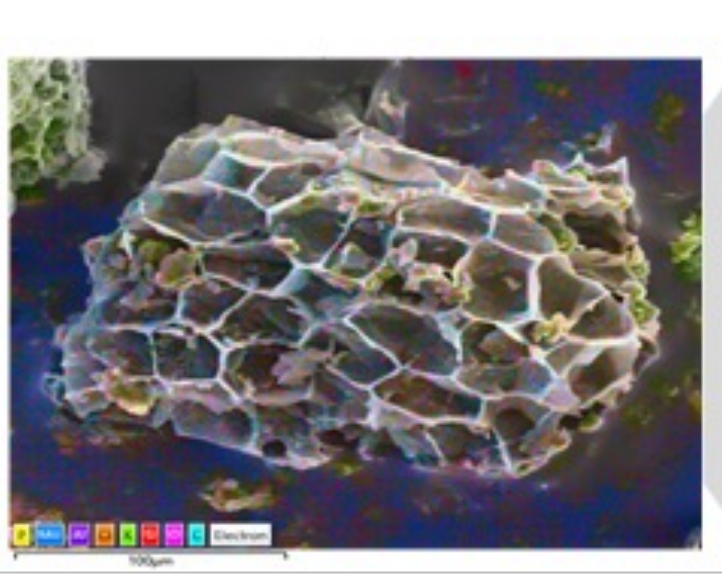


Figure 1 Surface morphology of synthesized coffee pulp biochar at different magnification of (a) 500x, (b) 1000x, and (c) 5000x.



Element	Average weight(%)
C	66.60
O	19.13
K	11.63
Mo	1.43
P	0.93
Cl	0.23
Si	0.07

Figure 2 Element components of coffee pulp biochar.

Acknowledgement

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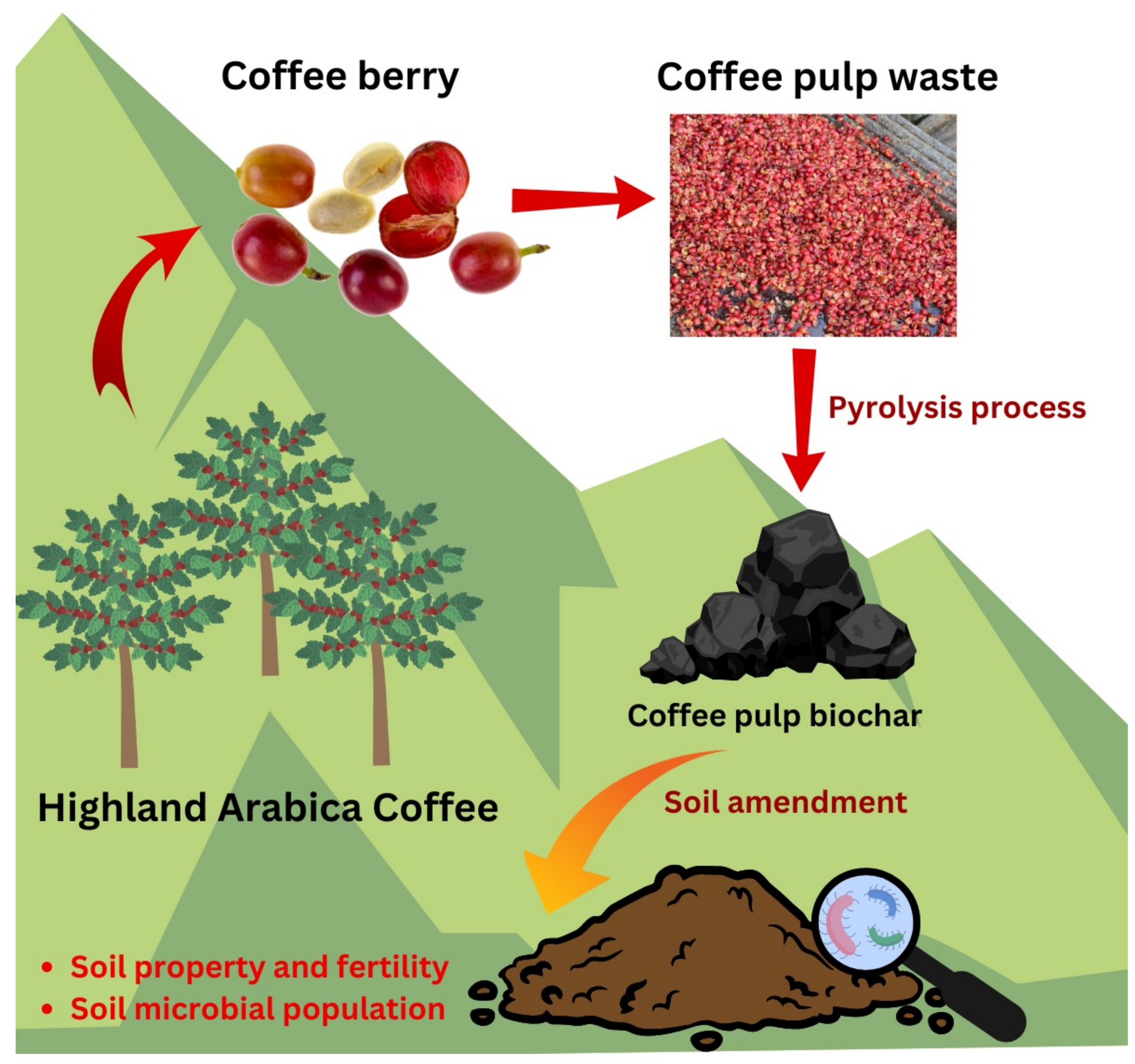
Introduction



The objective : to characterize coffee pulp biochar and its effects on soil properties and microbial populations, aiming to develop effective waste management strategies for highland areas in northern Thailand.

Results

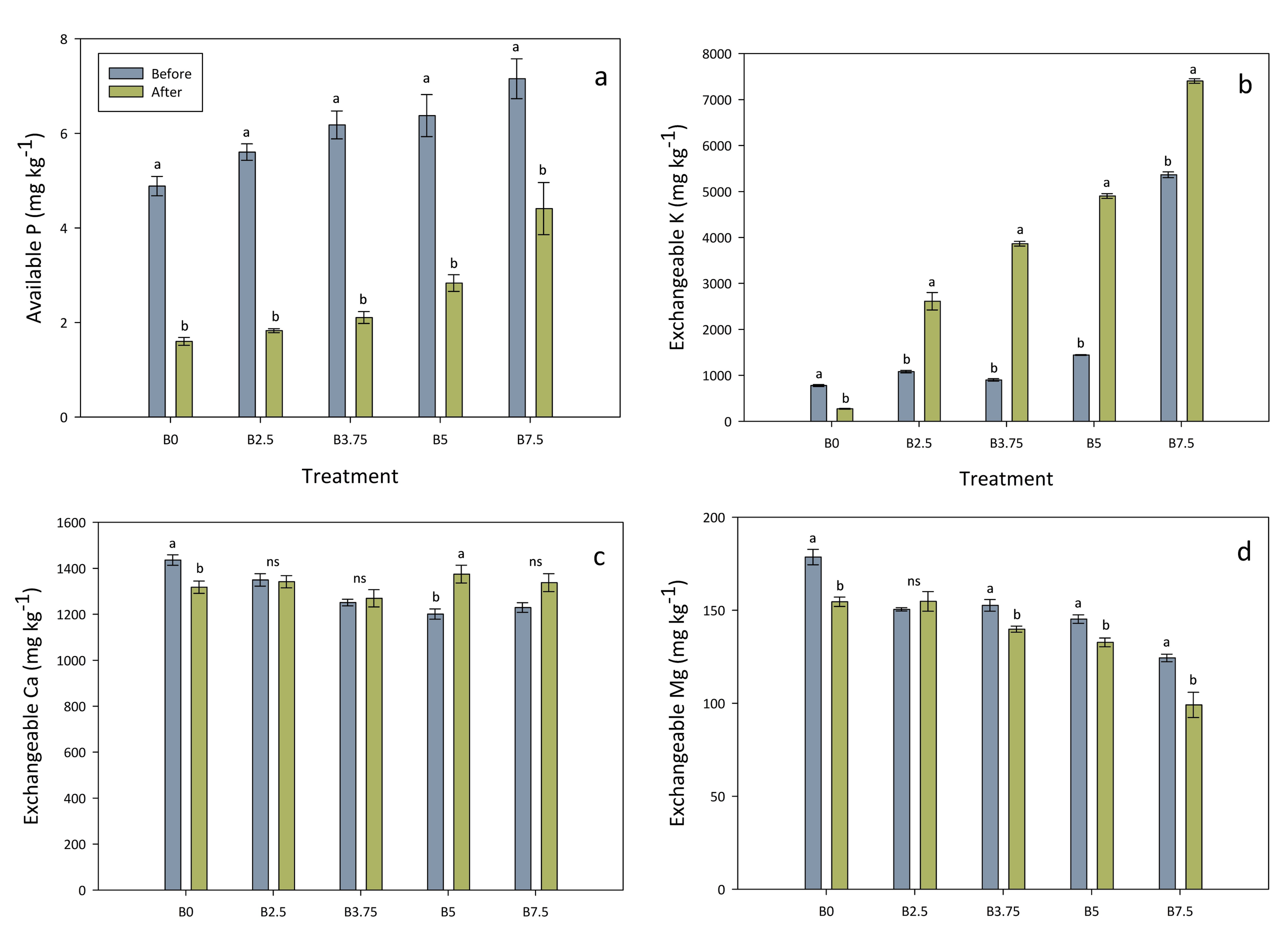


Figure 3 Levels of (a) Available P, (b) Exchangeable K, (c) Exchangeable Ca, and (d) Exchangeable Mg before and after treatment with coffee pulp biochar at different concentrations (B0: control, B2.5: 2.5%, B3.75: 3.75%, B5: 5%, B7.5: 7.5%).

Adding coffee biochar significantly increased available P content in proportion to the biochar percentage applied before treatment, but a decrease was observed after treatment ($P < 0.05$) (Figure 3(a)). For Exchangeable K, values increased significantly with the percentage of coffee biochar both before and after treatment ($P < 0.05$) (Figure 3(b)). A significant increase in Exchangeable K was found when comparing pre- and post-treatment values, except in the control group. This is due to the high potassium content in coffee biochar (11.63% K) as shown in Figure 2 Exchangeable Ca values significantly decreased with increasing biochar percentages before treatment, but showed no significant differences among treatments after treatment, except for the 5% biochar treatment which exhibited an increase ($P < 0.05$) (Figure 3(c)). For Exchangeable Mg, values significantly decreased with increasing biochar percentages both before and after treatment ($P < 0.05$) (Figure 3(d)).

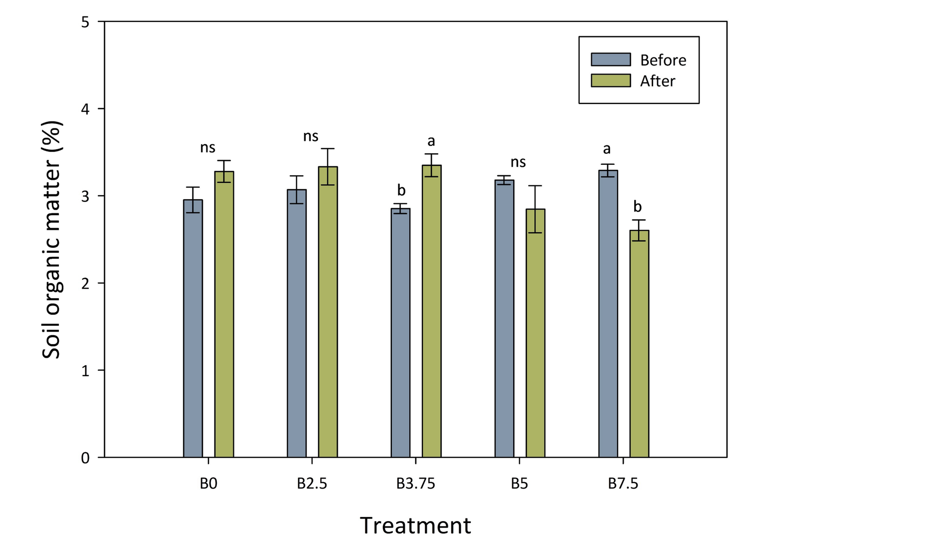


Figure 4 Soil organic matter percentage before and after treatment with coffee pulp biochar at different concentrations (B0: control, B2.5: 2.5%, B3.75: 3.75%, B5: 5%, B7.5: 7.5%).

Figure 4 shows that adding 3.75% coffee biochar by soil weight significantly increased %SOM after treatment ($P < 0.05$). In contrast, adding 7% biochar resulted in a significant decrease in %SOM post-treatment ($P < 0.05$).

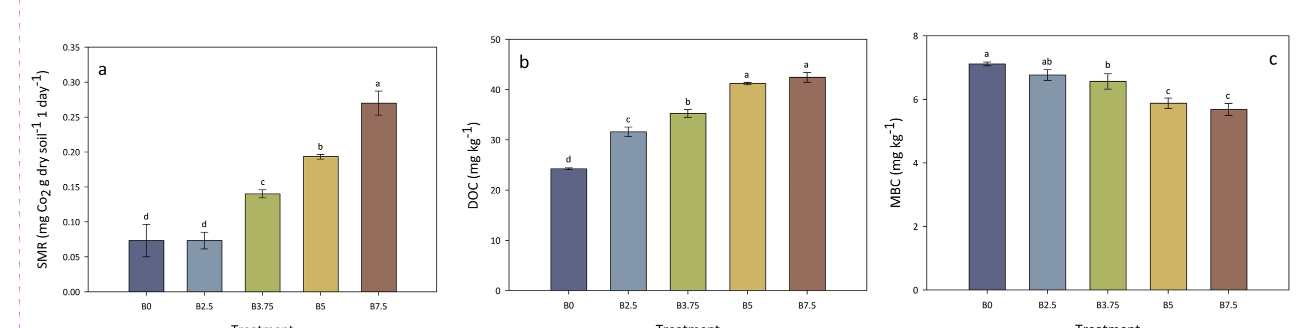


Figure 5 Levels of (a) Soil Microbial Respiration (SMR), (b) Dissolved Organic Carbon (DOC), and (c) Microbial biomass carbon (MBC) with coffee pulp biochar at different concentrations (B0: control, B2.5: 2.5%, B3.75: 3.75%, B5: 5%, B7.5: 7.5%).

After treatment with coffee biochar, SMR significantly differed among treatments ($P < 0.05$), with the highest increase observed at 7.5% biochar addition. Figures 5(a) and 5(b) show that SMR and DOC increased with higher percentages of biochar. Conversely, MBC decreased as the biochar percentage increased. The observed values for these parameters exhibited an inverse relationship. Overall, the application of coffee biochar resulted in an increase in SMR and DOC, while MBC showed a decreasing trend with higher biochar application rates.

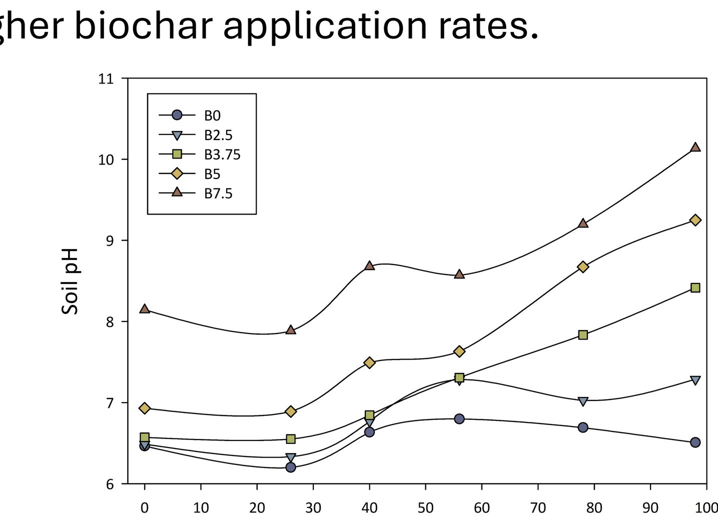


Figure 6 Levels of Soil pH from the start to day 98 with coffee pulp biochar at different concentrations (B0: control, B2.5: 2.5%, B3.75: 3.75%, B5: 5%, B7.5: 7.5%).

Figure 6 shows that after treatment with coffee biochar, pH values tend to increase, except in the control treatment without biochar.

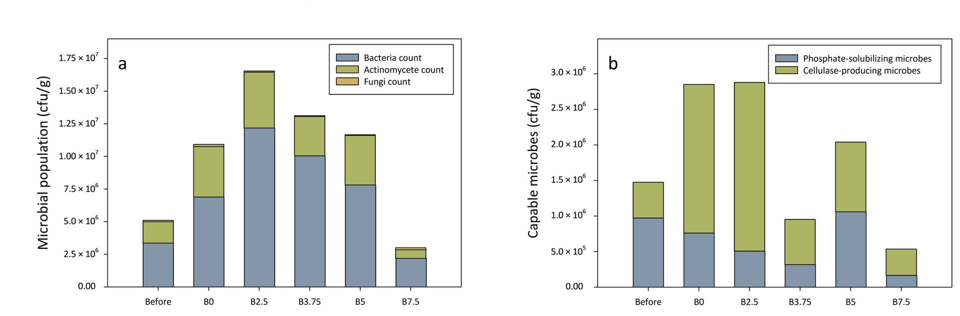


Figure 7 Count of (a) Microbial population and (b) Capable microbes with coffee pulp biochar at different concentrations (B0: control, B2.5: 2.5%, B3.75: 3.75%, B5: 5%, B7.5: 7.5%).

Figure 7(a) shows that treatment with coffee biochar generally increases bacteria and actinomycete populations, while fungi decrease, except at 7.5% biochar, where all populations decrease. Figure 7(b) indicates a reduction in cellulase-producing microorganisms and an increase in phosphate-solubilizing microorganisms after biochar treatment. Notably, at 5% biochar, there is an increase in bacteria, actinomycetes, cellulase-producing, and phosphate-solubilizing microorganisms, with a decrease in fungi.

Conclusion

The study on coffee pulp biochar reveals its impact on soil and microbial communities. Biochar increases available phosphorus, potassium, and soil pH, and enhances soil microbial respiration and dissolved organic carbon. It decreases microbial biomass carbon and shifts microbial populations, boosting bacteria and actinomycetes while reducing fungi. Notably, biochar treatment increases phosphate-solubilizing microorganisms and cellulase-producing microbes, particularly at a 5% application rate.