Application of Algal Biomass and Biochar in Combination with Actinobacteria to Promote the Growth of Lettuce

Pongsapak Prangkeaw, Wageeporn Maneechote, Antira Wichaphian, Jeeraporn Pekkoh, Wasu Pathomaree, Sirasit Srinuanpan*

Division of Microbiology, Department of Biology, Faculty of Science, Chiang Mai University, *Email : sirasit.s@cmu.ac.th

ABSTRACT

The widespread use of chemical fertilizers remains a key strategy for improving agricultural productivity. However, their long-term and intensive application can degrade soil quality, reduce microbial diversity, impair nutrient retention, and increase soil acidification, posing potential risks to farmers and consumers. This study investigated the effects of Spirulina biomass and biochar derived from *Spirulina* biomass, applied with or without the actinomycete *Streptomyces sampsonii* MFA02, on lettuce growth during a 28-day cultivation period. The experiment consisted of two main groups based on the presence or absence of *S. sampsonii* MFA02 inoculation. Each group included six treatments: *Spirulina* biomass (B), *Spirulina* biochar (Bc), chemical fertilizer (Ch), half-strength *Spirulina* biomass plus chemical fertilizer (B50+Ch50), half-strength *Spirulina* biochar plus chemical fertilizer (Bc50+Ch50), and half-strength *Spirulina* biomass plus *Spirulina* biochar (B50+Bc50), along with a control (no B, Bc, or Ch addition). Among all treatments, Bc50+Ch50 with actinomycete inoculation produced the greatest growth enhancement. Compared with the control, plant height, root length, leaf number, fresh weight, and dry weight increased by 1.30-, 1.06-, 2.00-, 6.70-, and 4.03-fold, respectively. Photosynthetic pigment contents also increased by 1.20–1.50-fold, indicating improved photosynthetic capacity. Higher soil carbon dioxide emissions were observed, suggesting enhanced microbial activity and nutrient cycling in the rhizosphere. Correlation analysis revealed strong positive relationships among growth parameters and close associations among pigment groups. Overall, the combined application of *Spirulina* biochar and *S. sampsonii* MFA02 achieved performance comparable to or exceeding that of chemical fertilizer alone. These findings highlight its potential as a sustainable strategy to reduce synthetic fertilizer inputs and support long-term agricultural sustainability.

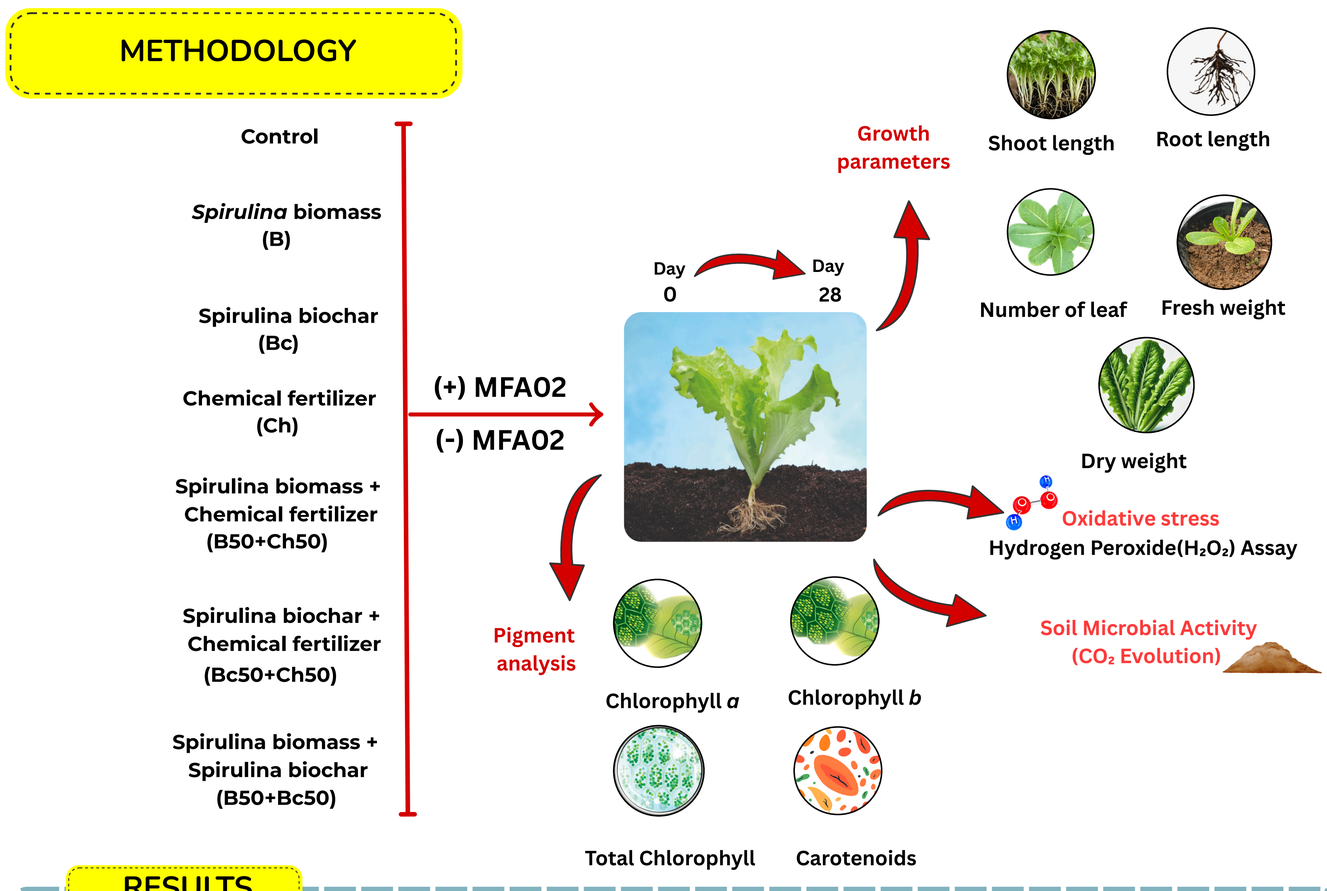
INTRODUCTION

Chemical fertilizers enhance agricultural productivity but have adverse effects on the environment and human health, leading to soil degradation and a decline in beneficial microbial diversity. Using biofertilizers derived from algal biomass and biochar offers a sustainable alternative. Algal biomass is rich in essential nutrients and plant hormones, promoting plant growth and increasing resilience to unfavorable environmental conditions. Meanwhile, biochar improves soil structure, enhances water and nutrient retention, and reduces nutrient leaching. Additionally, Actinobacteria play a crucial role in controlling plant pathogens, boosting plant immunity, and producing bioactive compounds that stimulate plant growth. This approach reduces the reliance on chemical fertilizers and pesticides, fostering environmentally friendly and sustainable agricultural practices.

OBJECTIVE

- To investigate the effectiveness of *Spirulina* sp. biomass and biochar derived from *Spirulina* sp. biomass in combination with actinomycetes to promote the growth of lettuce.
- To evaluate the impact on the growth performance of lettuce plants as a basis for developing a sustainable biofertilizer approach.

METHODOLOGY



RESULTS



Control



B (100% *spirulina* biomass)



Bc (100% *spirulina* biochar)



Ch (100% chemical fertilizer)



B50+Ch50 (50% *spirulina* biomass + 50% chemical fertilizer)



Bc50+Ch50 (50% *spirulina* biochar + 50% chemical fertilizer)



B50+Bc50 (50% *spirulina* biomass + 50% *spirulina* biochar)



Control + actinobacteria



B + acti (100% *spirulina* biomass + actinobacteria)



Bc + acti (100% *spirulina* biochar + actinobacteria)



Ch + acti (100% chemical fertilizer + actinobacteria)



B50+Ch50+acti (50% *spirulina* biomass + 50% chemical fertilizer + actinobacteria)



Bc50+Ch50+acti (50% algal biochar + 50% chemical fertilizer + actinobacteria)

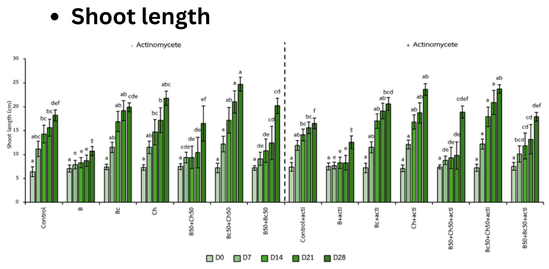


B50+Bc50+acti (50% *spirulina* biomass + 50% *spirulina* biochar+actinobacteria)

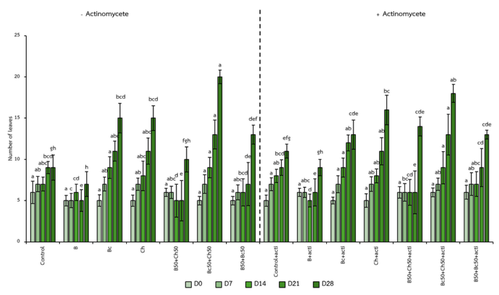
RESULTS

Growth parameter

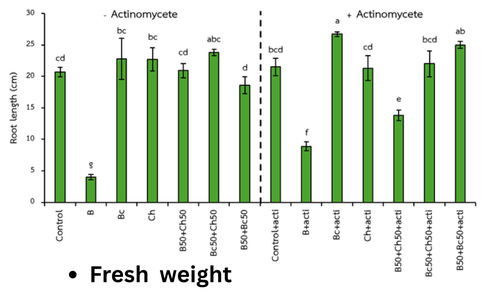
- **Shoot length**



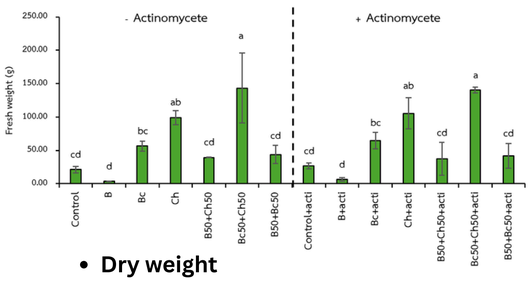
- **Number of leaves**



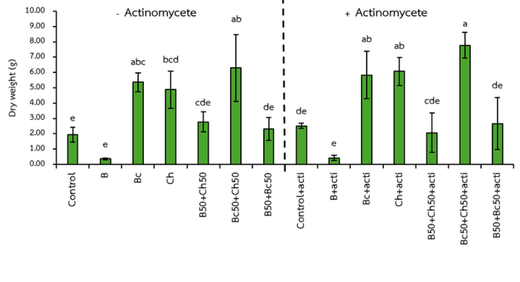
- **Root length**



- **Fresh weight**

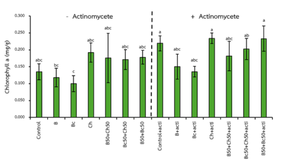


- **Dry weight**

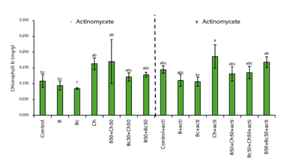


Pigment analysis

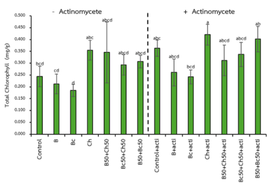
Chlorophyll a



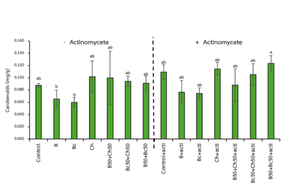
Chlorophyll b



Total chlorophyll

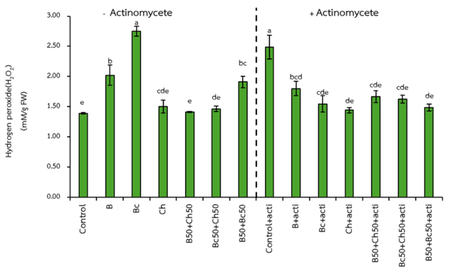


Carotenoids

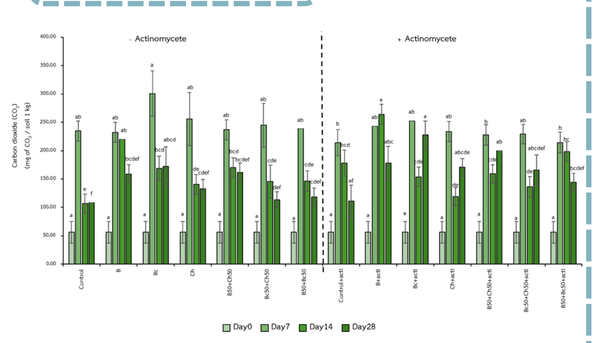


Oxidative stress

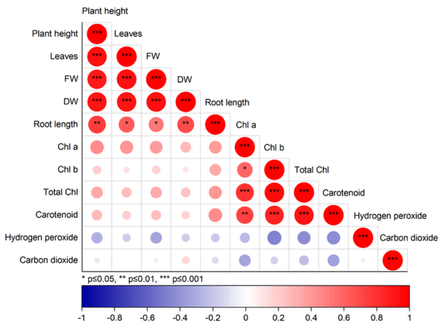
- **Hydrogen Peroxide (H_2O_2)**



Soil Microbial Activity



Pearson's Correlation Coefficient



CONCLUSION

Bc50+Ch50 (50% algal biochar + 50% chemical fertilizer) significantly enhanced lettuce growth both with and without actinomycete inoculation, increasing plant height, fresh weight, dry weight, and leaf number. In addition, biochar improved root length and nutrient uptake efficiency, while actinomycete inoculation further promoted pigment accumulation, reduced stress, and stimulated overall lettuce growth.

ACKNOWLEDGEMENTS

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