Physiological Responses of *Streptomyces thermocarboxydus* isolate S3 to Microplastics

Pinyapat Duenta* and Wasu Pathom-aree

Division of Microbiology, Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand

*Email: pinyapat_duenta@cmu.ac.th

Abstract

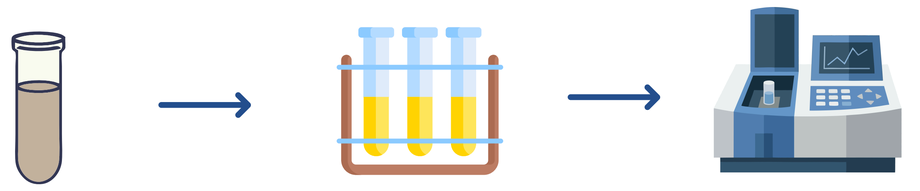
Microplastics are emerging environmental pollutants that are increasingly widespread in soils and can induce oxidative stress in soil microorganisms, which disrupts physiological balance and intracellular metabolic processes. However, knowledge of the response mechanisms of actinobacteria to microplastic exposure remain limited. This study aimed to investigate physiological responses and tolerance mechanisms of *Streptomyces thermocarboxydus* isolate S3 to microplastics, as well as to evaluate phytotoxicity of microplastics on lettuce seedling growth and mitigating potential of *S. thermocarboxydus* S3. Initially, three types of microplastics were tested at different concentrations to evaluate their effects on the growth of *S. thermocarboxydus* S3. These included polyethylene terephthalate (PET), polystyrene (PS), and polypropylene (PP). Microplastic types that showed stronger inhibitory effects on growth were selected for determination of tolerance mechanisms in *S. thermocarboxydus* S3. The experiment was divided into three parts. (1) Measurement of oxidative stress markers namely hydrogen peroxide (H_2O_2), hydroxyl radical (•OH) and MDA content. (2) Measurement of antioxidant enzyme activities namely superoxide dismutase (SOD), catalase (CAT), guaiacol peroxidase (GPX) and ascorbate peroxidase (APX). (3) Phytotoxicity assay based on seedling growth of lettuce (*Lactuca sativa* L. var. *longifolia*). Microplastics reduced *S. thermocarboxydus* S3 growth in a dose-dependent manner across all tested microplastic types with PET and PP showing the strongest inhibition. These two microplastic types were selected for further analyses. Both microplastics induced oxidative stress via the production of H_2O_2 and •OH in PP and PET exposure, respectively. PET induced more pronounced cellular damage compared to PP. In phytotoxicity assays, PET caused more severe reduction in lettuce seedling growth than PP exposure. Inoculation with *S. thermocarboxydus* S3 tended to increase seedling length and fresh weight compared with the control.

Objectives

- To investigate physiological responses of *S. thermocarboxydus* S3 to microplastics
- To evaluate phytotoxicity of microplastics on lettuce seedling growth and mitigating potential of *S. thermocarboxydus* S3

Methodology

Screening of *S. thermocarboxydus* S3 growth under microplastic exposure

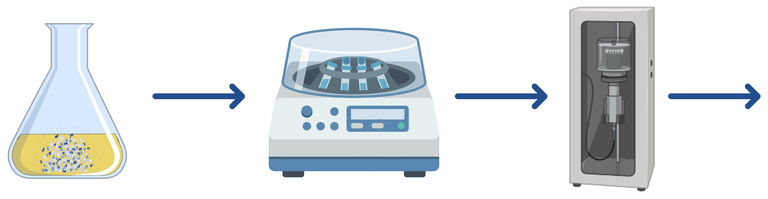


Spore suspension of *S. thermocarboxydus* S3 (OD_{600} = 1, 10^8 cfu/ml)

Cultured in 10% TSB, followed by PET, PP, PS exposure (0.1%, 1%, 5% w/v)

OD_{600} measurement

Responses of *S. thermocarboxydus* S3 to microplastic exposure



S3 cultured in 10% TSB and exposed to 1% (w/v) PET and PP for 12 h

Cells harvested by centrifugation

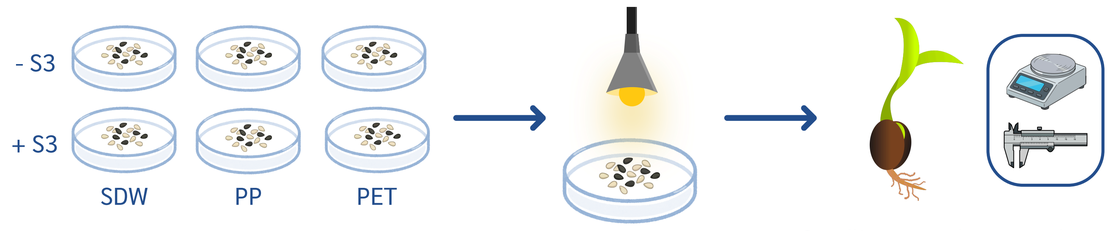
Cell pellets were sonicated to obtain intracellular extracts

Biochemical analysis

Oxidative stress markers
- H_2O_2, •OH and MDA

Antioxidant enzyme activities
- SOD, CAT, GPX and APX

Phytotoxicity of microplastics on lettuce seedling growth



Seeds were exposed to PET, and PP treatments with or without S3 inoculation

Seeds were incubated for 7 days

Seedling growth was evaluated based on seedling length, fresh weight and dry weight

Results

Screening of growth under microplastic exposure

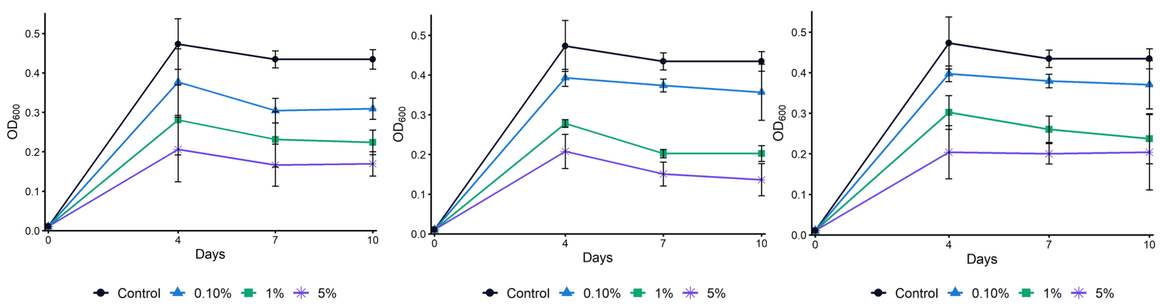


Figure 1. Growth response of *S. thermocarboxydus* S3 exposed to (a) PET, (b) PP, and (c) PS at 0.1%, 1%, and 5% (w/v).

- Growth decreased in a dose-dependent manner

Oxidative stress markers

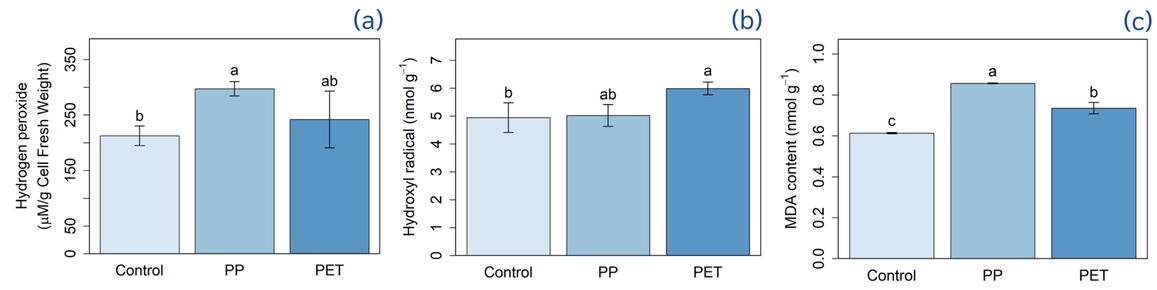


Figure 2. (a) H_2O_2 level, (b) •OH level, and (c) MDA content in *S. thermocarboxydus* S3 under PP and PET exposure compared with the control.

Antioxidant enzyme activities

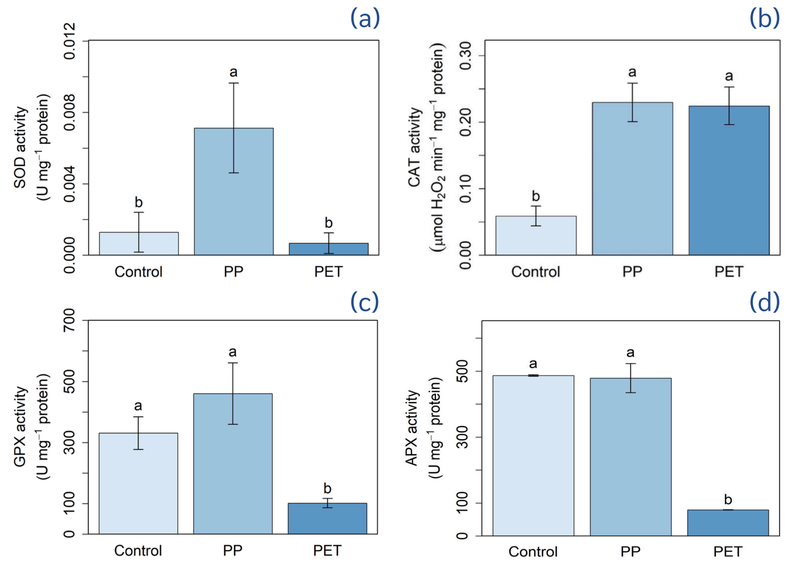


Figure 3. (a) SOD activity, (b) CAT activity, (c) GPX activity and (d) APX activity in *S. thermocarboxydus* S3 under PP and PET exposure compared with the control.

Phytotoxicity assay

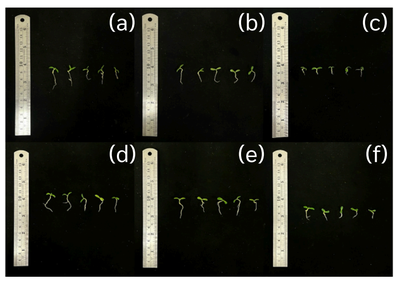


Figure 4. Morphology of lettuce seedlings under different treatments: (a) sterile distilled water (SDW) without S3, (b) PP without S3, (c) PET without S3, (d) SDW with S3, (e) PP with S3 and (f) PET with S3.

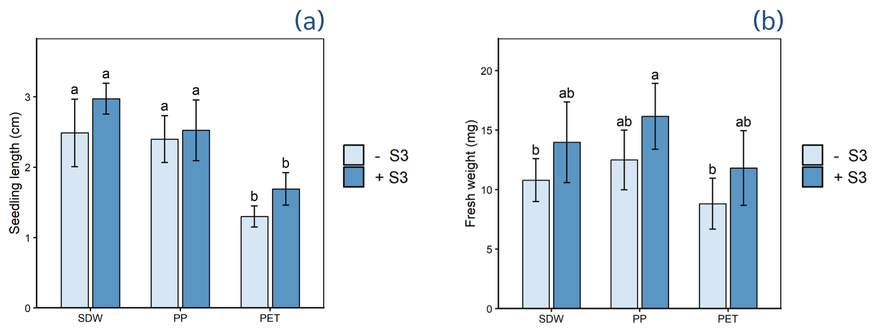


Figure 5. Phytotoxic effects of PP and PET on lettuce seedlings: (a) seedling length and (b) fresh weight.

Conclusion

Microplastics reduced growth of *S. thermocarboxydus* S3 in a dose-dependent manner. Exposure to PP and PET significantly increased levels of H_2O_2 and •OH, respectively which led to cell membrane damage via lipid peroxidation. *S. thermocarboxydus* S3 mitigates this oxidative stress with the production of antioxidative enzymes, catalase and SOD for PP and catalase for PET exposure. In phytotoxicity assay, PET significantly reduced lettuce seedling length. However, inoculation with *S. thermocarboxydus* S3 provided an improvement in seedling length and fresh weight compared with the control.

Acknowledgements

The author gratefully acknowledges Ms. Benyapa Kitwetch, Ms. Mathurin Meetangdee, and members of the Microbiology Laboratory ScB2806 for their support.

References

- Qin, P., *et al*. (2023). Sci. Total Environ. 857:159440.
- Parsaeimehr, A., *et al*. (2023). Heliyon. 9(4):e15104.
- Gao, J., *et al*. (2025). Toxics. 13(9):706.
- Ghosh, S., *et al*. Int. J. Plant Soil Sci. 37:61-74.