Drought Tolerance Mechanisms of Plant Growth-Promoting Actinobacterium *Streptomyces gardneri* MC1-2

Pornprom Meekrut* and Pharada Rangseekaew

Microbiology Division, Department of Biology, Faculty of science, Chiang Mai University, Chiang Mai, 50200, Thailand

*Email : pornprom_m@cmu.ac.th

Abstract

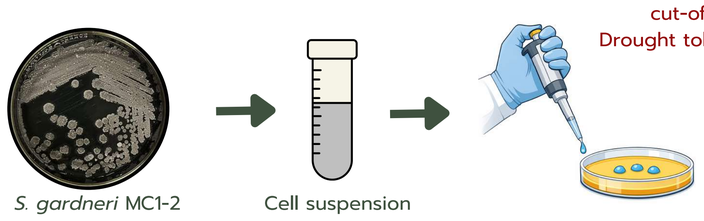
Drought stress is a major factor limiting agricultural productivity worldwide. The application of plant growth–promoting actinobacteria has gained increasing attention as a strategy to enhance crop drought resilience. *Streptomyces gardneri* MC1-2 has been reported to exhibit plant growth–promoting traits, including indole-3-acetic acid (IAA) and siderophore production, phosphate solubilization, and the ability to alleviate drought stress in tomato plants. This study aimed to investigate drought tolerance mechanisms of *S. gardneri* MC1-2 using physiological and genome analysis. The results revealed that *S. gardneri* MC1-2 exhibited drought tolerance, as evidenced by its ability to grow on medium supplemented with 660 g/L sorbitol (water activity, a_w=0.884). To investigate drought tolerance mechanisms, *S. gardneri* MC1-2 was cultured in ISP2 broth supplemented with 405 g/L sorbitol to simulate drought stress, while medium without sorbitol served as the unstressed control. Under drought stress, *S. gardneri* MC1-2 enhanced osmolyte accumulation, particularly intracellular total soluble sugars (TSS) and proline. The strain grown under drought stress exhibited higher malondialdehyde (MDA) levels than the control, indicating increased lipid peroxidation and oxidative damage. Nevertheless, it activated oxidative stress defense mechanisms by enhancing non-enzymatic antioxidant activity, as determined by ABTS and DPPH assays, and increasing antioxidant enzyme activities, particularly catalase and superoxide dismutase, accompanied by reduced hydrogen peroxide levels. Genome analysis using the RAST server and antiSMASH 8.0 confirmed the presence of genes associated with plant growth promoting traits and oxidative and osmotic stress responses. These findings elucidate the physiological and genomic basis of drought tolerance in *S. gardneri* MC1-2 and support its potential application in improving plant resilience under arid conditions.

Objective

To study the drought tolerance mechanisms of *Streptomyces gardneri* MC1-2 by physiological and genomic analyses

Methodology

Drought tolerance assay

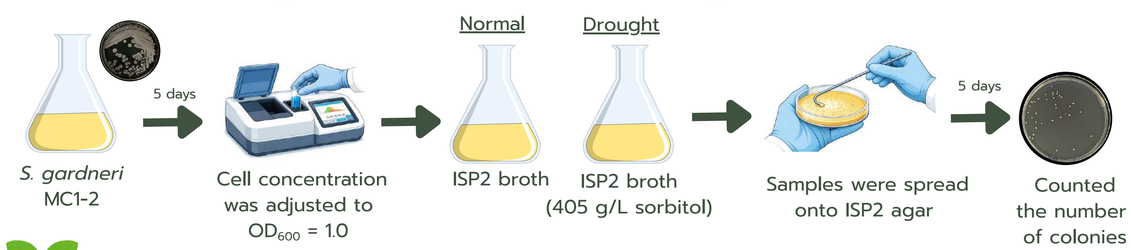


Sorbitol (g/L)	Water activity (a_w)
0	0.998
85	0.986
285	0.957
405	0.919
520	0.897
660	0.844

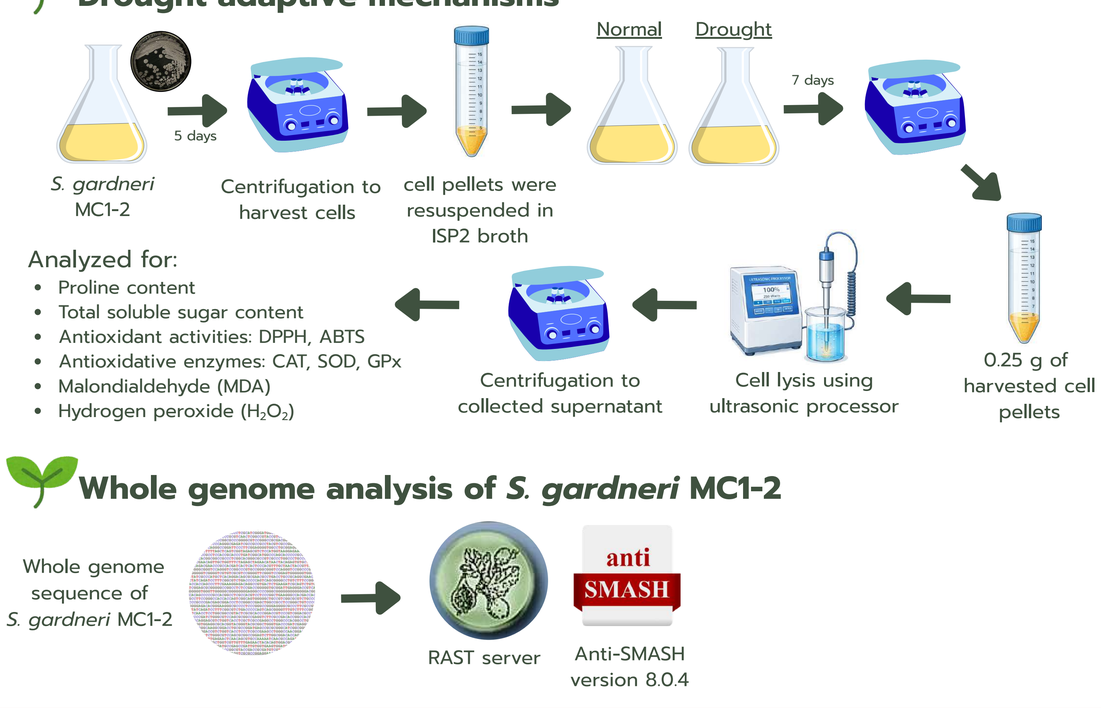
cut-off Drought tolerance

20 µL of cell suspension was dropped onto ISP2 agar containing different concentrations of sorbitol

Growth of *S. gardneri* MC1-2 under drought



Drought adaptive mechanisms



Analyzed for:

- Proline content
- Total soluble sugar content
- Antioxidant activities: DPPH, ABTS
- Antioxidative enzymes: CAT, SOD, GPx
- Malondialdehyde (MDA)
- Hydrogen peroxide (H_2O_2)

Whole genome analysis of *S. gardneri* MC1-2

Conclusion

Streptomyces gardneri MC1-2 exhibited drought tolerance. Its drought stress adaptation was associated with significant increases in accumulation of proline and total soluble sugars inside the cell, as well as increased catalase and superoxide dismutase activities, and enhanced antioxidant activity measured by ABTS assay. Moreover, genomic analysis using the RAST server revealed the presence of genes related to plant growth promotion and genes involved in osmotic and oxidative stress response.

Results

Drought tolerance ability

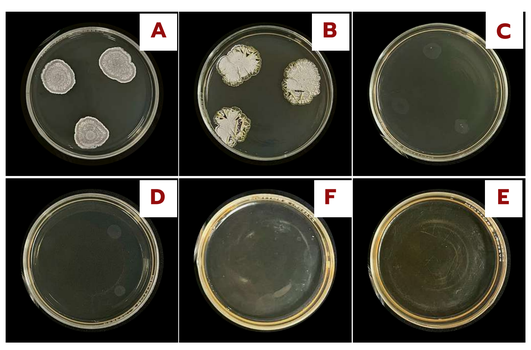


Figure 1 Growth of *S. gardneri* MC1-2 on ISP2 supplemented with difference concentrations of sorbitol. (A) 0 g/L; (B) 85 g/L; (C) 285 g/L; (D) 405 g/L; (E) 520 g/L; (F) 660 g/L

Growth of *S. gardneri* MC1-2

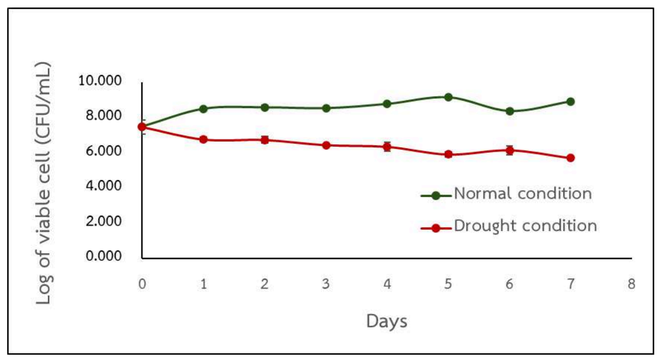


Figure 2 Growth curve of *S. gardneri* MC1-2 under normal and drought conditions.

Drought adaptive mechanisms of *S. gardneri* MC1-2

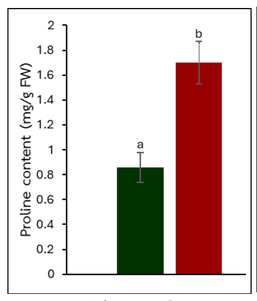


Figure 3 Proline content

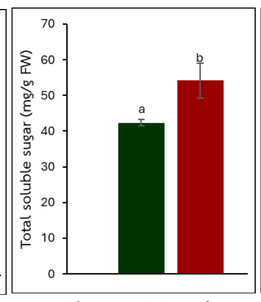


Figure 4 Total soluble sugar (TSS)

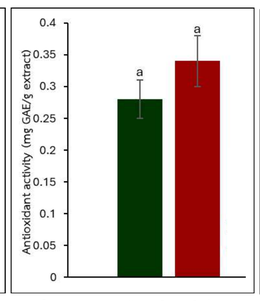


Figure 5 Antioxidant activity (DPPH assay)

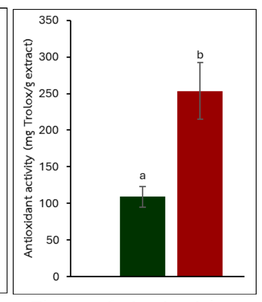


Figure 6 Antioxidant activity (ABTS assay)

Normal condition

Drought condition

NOTE: Statistical analysis was performed using an independent samples t-test (p-value < 0.05). Different letters indicate significant differences between normal condition and drought condition.

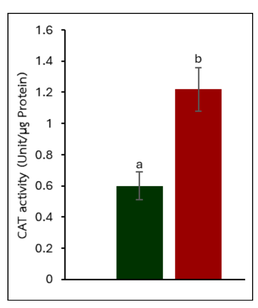


Figure 7 Catalase activity

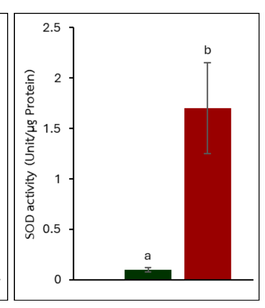


Figure 8 Superoxide dismutase activity

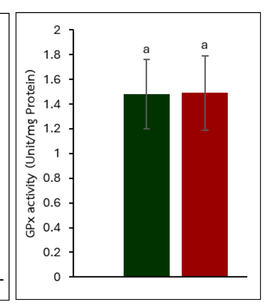


Figure 9 Glutathione peroxidase activity

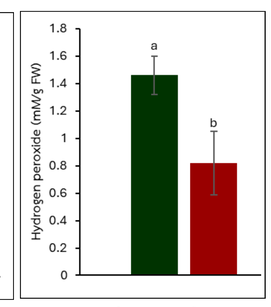


Figure 10 H_2O_2 content

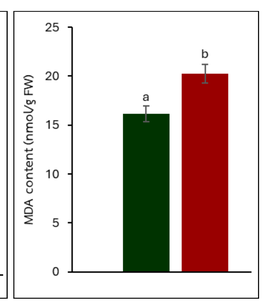
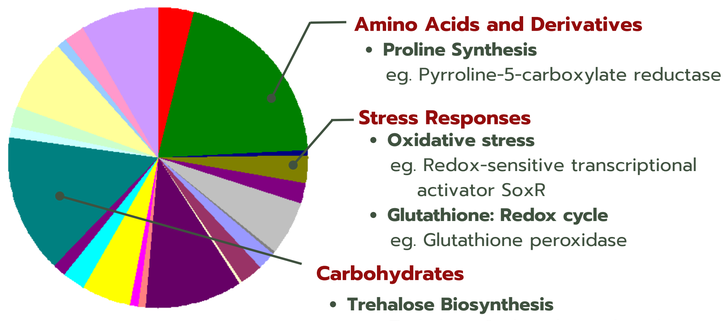


Figure 11 Malondialdehyde content

Whole genome analysis of *S. gardneri* MC1-2

- **RAST server**



- **Anti-SMASH version 8.0.4**

Region	Type	Similarity Confidence
1.5	ectoine	High
5.1	NI-siderophore: desferrioxamine B/desferrioxamine	Low

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