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Effects of hot spring-derived photosynthetic bacteria on growth and quality of chinese kale (*Brassica oleracea* var. alboglabra) seedlings

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Abstract

Photosynthetic bacteria have emerged as a promising biological approach for promoting sustainable agriculture, capable of enhancing plant growth through phytohormone production, nitrogen fixation, and improved stress tolerance. Bacteria isolated from extreme environments, such as hot springs, may possess unique physiological traits that further support plant growth promotion. The increasing demand for sustainable food production systems has driven interest in identifying effective microbial biostimulants that can reduce dependence on chemical fertilisers. This study evaluated the effects of photosynthetic bacteria isolated from San Kamphaeng hot springs, Chiang Mai, Thailand, on the growth performance and quality of Chinese kale (*Brassica oleracea* var. alboglabra) seedlings. Five isolates (H1–H5) were tested under a randomised complete block design (RCBD) with six treatments and four replications, including an uninoculated control, to evaluate growth performance, nutrient uptake, and photosynthetic pigment accumulation. Isolate H3 significantly enhanced plant height, root length, fresh weight, and dry weight across all observation periods (7, 14, 21, 28, and 35 days after sowing) ($p = 0.001$), and improved nutrient uptake, with values of 15.63 mg N plant^{-1}, 1.53 mg P plant^{-1}, and 1.45 mg K plant^{-1} ($p = 0.005$). Isolate H2 showed distinct advantages in photosynthetic pigment accumulation, with chlorophyll a, chlorophyll b, total chlorophyll, and carotenoid contents of 3.75, 2.00, 4.22, and 4.21 mg L^{-1}, respectively ($p = 0.001$). Additionally, inoculation enhanced microbial diversity in the growing medium compared to the control. These findings suggest that photosynthetic bacteria from hot spring environments have potential as microbial biostimulants that can enhance plant growth, nutrient use efficiency, and physiological attributes in Chinese kale seedlings. Isolates H3 and H2 are promising candidates for field-based applications, supporting sustainable and climate-resilient agricultural systems. Future studies should assess their efficacy under field conditions and soil microbiome interactions to validate their potential as bioinoculants in sustainable crop production.

Keywords: Hot spring, microbial biostimulants, photosynthetic bacteria, plant growth promotion, sustainable agriculture

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