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Characterization of a Versatile Plant Growth-Promoting Rhizobacterium *Pseudomonas mediterranea* Strain S58

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Abstract: Plant growth-promoting rhizobacterial strain S58 was isolated from the tobacco rhizosphere. It showed strong antagonism against a battery of plant pathogenic fungi and bacteria, and controlled wheat sharp eyespot and tobacco wildfire diseases efficiently. Further tests showed that strain S58 solubilized organic phosphate and produced siderophore, protease, ammonia, and indole-3-acetic acid. In *Arabidopsis thaliana*, it promoted plant growth and changed root system architecture by restricting the growth of primary roots and increasing lateral root numbers. We relied on morphological, biochemical, physiological characteristics, and molecular phylogenic analysis to identify strain S58 as *Pseudomonas mediterranea*. The complete genome of strain S58 has a single circular chromosome of 6,150,838 bp with a 61.06% G+C content. The bacterial genome contained 5,312 predicted genes with an average length of 992.90 bp. A genome analysis suggested that *P. mediterranea* S58 was a rich cyclic lipopeptide (CLP)-producing strain that possessed seven non-ribosomal peptide gene clusters for CLP synthesis. Leaf inoculation of the bacterial culture and supernatants triggered cell death-like immunity in tobacco. Quantitative real-time PCR assays showed that the strain S58 induced the expression of pattern-triggered immunity and cell death marker genes, but not jasmonic acid marker genes. The results suggested that *P. mediterranea* S58 is a novel, versatile plant growth-promoting agent with multiple beneficial traits for plants.

Keywords: *Pseudomonas mediterranea*; biological control; cyclic lipopeptide; cell death

1. Introduction

Beneficial microbes have received a great deal of attention as a sustainable alternative for improving plant health. *Pseudomonas* is a well-known plant growth-promoting rhizobacterial (PGPR) genus for its multifarious plant beneficial functions. The mechanisms of a class of *Pseudomonas* species, such as *P. fluorescens*, *P. protegens*, *P. chlororaphis*, and *P. putida*, have been studied intensively and used widely in agricultural applications [1,2]. The PGPR *Pseudomonas* strains exert positive effects on plants in many ways, such as direct antagonism against pathogens, induction of plant resistance and immunity, alteration of plant growth morphology, toleration of environmental stress, and utilization of minerals [3,4]. Cyclic lipopeptides (CLPs) and polyketides that are synthesized by non-ribosomal peptide synthetases (NRPS) and by polyketide synthases (PKS), respectively, are major antimicrobial secondary metabolites produced by PGPR *Pseudomonas* [5–7]. *Pseudomonas* isolates, such as *P. kilonensis* F113, *P. protegens* Pf-5, and *P. fluorescens* SBW25 and 2P24 produced 2,4-diacetylphloroglucinol (DAPG), phenazines, pyoluteorin, pyrrolnitrin, viscosin, orfamide A, and amphisin to inhibit a broad range of plant pathogens directly [8–11]. In addition to secondary metabolite-mediated, antagonistic effects on pathogens, the biological control activity of *Pseudomonas*