Microbiological Research 172 (2015) 7–15

Contents lists available at ScienceDirect

Microbiological Research

journal homepage: www.elsevier.com/locate/micres

Paenibacillus yonginensis DCY84^T induces changes in *Arabidopsis thaliana* gene expression against aluminum, drought, and salt stress

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ARTICLE INFO

Article history:
Received 11 December 2014
Received in revised form 9 January 2015
Accepted 11 January 2015
Available online 19 January 2015

Keywords:
Plant growth-promoting bacteria
Paenibacillus
Salt stress
Drought stress
Aluminum stress

ABSTRACT

Current agricultural production methods, for example the improper use of chemical fertilizers and pesticides, create many health and environmental problems. Use of plant growth-promoting bacteria (PGPB) for agricultural benefits is increasing worldwide and also appears to be a trend for the future. There is possibility to develop microbial inoculants for use in agricultural biotechnology, based on these beneficial plant–microbe interactions. For this study, ten bacterial strains were isolated from Yongin forest soil for which *in vitro* plant-growth promoting trait screenings, such as indole acetic acid (IAA) production, a phosphate solubilization test, and a siderophore production test were used to select two PGPB candidates. *Arabidopsis thaliana* plants were inoculated with *Paenibacillus yonginensis* DCY84^T and *Micrococcus yunnanensis* PGPB7. Salt stress, drought stress and heavy metal (aluminum) stress challenges indicated that *P. yonginensis* DCY84^T-inoculated plants were more resistant than control plants. *AtRSA1*, *AtVQ9* and *AtWRKY8* were used as the salinity responsive genes. The *AtERD15*, *AtRAB18*, and *AtLT178* were selected to check *A. thaliana* responses to drought stress. Aluminum stress response was checked using *AtAIP*, *AtALS3* and *AtALMT1*. The qRT-PCR results indicated that *P. yonginensis* DCY84^T can promote plant tolerance against salt, drought, and aluminum stress. *P. yonginensis* DCY84^T also showed positive results during *in vitro* compatibility testing and virulence assay against *X. oryzae* pv. *oryzae* Philippine race 6 (PXO99). Better germination rates and growth parameters were also recorded for the *P. yonginensis* DCY84^T Chuchung cultivar rice seed which was grown on coastal soil collected from Suncheon. Based on these results, *P. yonginensis* DCY84^T can be used as a promising PGPB isolate for crop improvement.

1. Introduction

Plant growth-promoting bacteria (PGPB) include species which form specific symbiotic relationships with plants (*e.g.*, *Rhizobia* spp. and *Frankia* spp.), those which are free-living, bacterial endophytes which can colonize some or a portion of a plant's interior tissues, and cyanobacteria (Bashan et al. 2004). PGPB are bacterial strains isolated from diverse environments which are able to beneficially affect many parameters of plant growth and yield, directly or indirectly (Diaz-Zorita and Fernandez-Canigia 2009). Plant growth is directly promoted by PGPB either by facilitating nutrition uptake or by modulating the plant hormone levels. Indirect promotion of plant growth occurs *via* PGPBs decreasing the inhibitory effects of various pathogenic agents on plant growth and development (*i.e.*, acting as a biocontrol agent). The protection is typically manifested as both a reduction in abiotic stress symptoms and inhibition of pathogen growth (biotic stress), which can be phenotypically similar to pathogen-induced systemic acquired resistance (SAR) or induction of systemic resistance (ISR, Ross 1961). This PGPB effect has been demonstrated in different plant species, such as bean, carnation, cucumber, radish, tobacco, tomato, and in the model plant *A. thaliana* (Van Loon et al. 1998). Although it is well known that SAR or ISR triggered by PGPB confers resistance against pathogen-induced plant diseases, a few published reports suggest

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http://dx.doi.org/10.1016/j.micres.2015.01.007
0944-5013/