PHOTOSYNTHETICA 54 (X): XXX-XXX, 2016

Molecular characterization of 5 chlorophyll *a/b*-binding protein genes from *Panax ginseng* Meyer and their expression analysis during abiotic stresses ♠

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Abstract

The chlorophyll *a/b*-binding protein (CAB) serves in both photosystems (PS), I and II, as a coordinator of antenna pigments in the light-harvesting complex (LHC). The CABs constitute abundant and important proteins in the thylakoid membrane of higher plants. In our study, five *CAB* genes, which contained full-length cDNA sequences from the 4-year-old ginseng leaves (*Panax ginseng* Meyer), were isolated and named *PgCAB*. Phylogenetic comparison of the members of the subfamily between ginseng and higher plants, including *Arabidopsis*, revealed that the putative functions of these ginseng CAB proteins were clustered into the different family of *Arabidopsis* CABs; two PgCABs in LHCII family and three PgCABs in LHCI family. The expression analysis of *PgCAB*s consistently showed dark-dependent inhibition in leaves. Expression analysis during abiotic stress identified that *PgCAB* genes responded to heavy metal, salinity, chilling, and UV stresses differently, suggesting their specific function during photosynthesis. This is the first comprehensive study of the *CAB* gene family in *P. ginseng*.

Additional key words: gene expression; gene isolation.

Introduction

Sunlight is the source of nearly all the metabolic energy driving life processes in all organisms by the photosynthetic process which converts light into chemical energy in photosynthetic organisms, such as cyanobacteria, green algae, and higher plants (Wientjes *et al.* 2013). All oxygenic photosynthetic organisms have photosystem (PS) I and II, numbered according to the historical order in which they were discovered; excitation of PSII produces a strong oxidant capable of splitting water; operation of PSI leads to formation of a reductant that is powerful enough to reduce nicotinamide adenine dinucleotide phosphate ($NADP^+$) (Foyer and Noctor 1999). Light harvesting is the first step in the photosynthesis process, therefore the light-harvesting antenna has to be regulated in response to their physiological status and the environmental signals. Chlorophyll ligated to light-harvesting complex (LHC) proteins and carotenoids mainly serve as antenna in algae and higher plants (Green and Durnford 1996, Chitnis 2001, Gobets and van Grondelle 2001, Melkozernov 2001, Wientjes *et al.* 2013).

The evolution of the photosynthetic machineries is closely connected to the extended LHC protein superfamily; LHC protein superfamily comprises several families, including LHC protein, LHC-like protein, the red lineage CAB-like protein, and the S subunit of PSII (PSBS) protein family (Engelken *et al.* 2010, 2012). The LHC protein family is divided into the subfamilies of the chlorophyll *a*-binding (CAA) proteins, the chlorophyll *a/b*-binding (CAB) proteins, the chlorophyll a/c-binding (CAC) proteins, and the lesser known LHC clades including LHCx and LHCz. Higher

Received 7 July 2015, *accepted* 11 November 2015.
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Abbreviations: CAB – chlorophyll *a/b*-binding protein; EST – expressed sequence tags; MS – Murashige and Skoog; ROS – reactive oxygen species; Pg – *Panax ginseng*; At – *Arabidopsis thaliana*; Rc – *Ricinus communis*; Pv – *Phaseolus vulgaris*.
Acknowledgments: This research was supported by Basic Science Research Program, National Reseach Foundation (NRF), Ministry of Education, Republic of Korea (2013R1A1A2064430) to Y.J. Kim and Korea Institute of Planning and Evaluation for Technology in Food, Agriculture, Forestry and Fisheries, Republic of Korea (iPET, 112142-05-1-CG000) to D.C. Yang.