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RESEARCH PAPER

Functional characterization of the three genes encoding 1-deoxy-D-xylulose 5-phosphate synthase in maize

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Abstract

The 1-deoxy-D-xylulose 5-phosphate synthase (DXS) enzyme catalyses the first biosynthetic step of the 2-*C*-methyl-D-erythritol 4-phosphate (MEP) pathway. In plants the MEP pathway is involved in the synthesis of the common precursors to the plastidic isoprenoids, isopentenyl diphosphate and dimethylallyl diphosphate, in plastids. DXS is recognized as limiting this pathway and is a potential target for manipulation to increase various isoprenoids such as carotenoids. In *Zea mays* three *dxs* genes exist that encode plastid-targeted functional enzymes. Evidence is provided that these genes represent phylogenetically distinctive clades conserved among plants preceding monocot–dicot divergence. There is differential accumulation for each *dxs* gene transcript, during development and in response to external signals such as light. At the protein level, the analysis demonstrates that in *Z. mays,* DXS protein is feedback regulated in response to the inhibition of the pathway flow. The results support that the multilevel regulation of DXS activity is conserved in evolution.

Key words: 1-Deoxy-D-xylulose 5-phosphate synthase (DXS), isoprenoid biosynthesis, maize, 2-*C*-methyl-D-erythritol 4-phosphate (MEP) pathway, post-transcriptional regulation.

Introduction

Plants produce many isoprenoids that are functionally important in essential processes. Despite their diversity, all isoprenoids are formed from two common precursors, isopentenyl diphosphate (IPP) and its isomer dimethylallyl diphosphate (DMAPP). Additionally isoprenoids are of biotechnological, medical, and industrial importance (Lange and Croteau, 1999; Römer *et al.*, 2000, and references within), prompting efforts to increase levels of these valuable compounds.

In plants, the biosynthesis of IPP and DMAPP utilizes two independent pathways that have different precursors. The acetate/mevalonate (MVA) pathway is found in most eukaryotes. The second pathway known as the 2-*C*-methyl-D-erythritol 4-phosphate (MEP) pathway operates in the chloroplast of photosynthetic eukaryotes and also in most eubacteria and in apicomplexa parasites (Eisenreich *et al.*, 2004). Thus, the genes and enzymes of the MEP pathway are attractive targets to develop new antibacterial and antiparasitic drugs, and herbicides (Rodríguez-Concepción, 2004; Rohdich *et al.*, 2005). Although evidence supports a limited exchange of intermediates between these two pathways, it is clear that only one pathway is primarily responsible for the synthesis of particular isoprenoids. The MVA pathway provides the precursors for sesquiterpenes (C_{15}) and triterpenes (C_{30}) (Lichtenthaler, 1999; Eisenreich *et al.*, 2001). In contrast,